CALIFORNIA HARBORS

Contents

REPORT

ON

RICHMOND HARBOR PROJECT

WITH
SUPPLEMENTARY REPORT
ON

TUNNEL AND ROADWAY

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TO THE COUNCIL OF THE CITY OF RICHMOND

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PART I

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Harbor and Terminal Developments in San Francisco Bay

CHAPTER I

REQUIREMENTS FOR PORT DEVELOPMENT.

The essential requirements for a great seaport are:

First—A thickly settled, tributary territory, producing exports and consuming imports in large quantities.

Second—A commodious, sheltered, deep water harbor, affording ample anchorage for shipping of any draught, and with a safe and easily approached entrance channel.

Third—Deep water wharves, piers or quays so located and constructed that ships can cheaply and quickly load or unload freight or passengers and can temporarily store freight until it can be started on its final destination.

Because it is cheaper to move freight on deep natural waterways, than on land, harbors are located as far inland or as far toward the center of the productive, tributary area as possible. In recent years the rapidity and economy of freight movement on land has very greatly increased, so that the area of producing and consuming territory, tributary to any great port has rapidly enlarged. This seems to be the chief influence which has had such an evident effect in recent times of crystallizing and centralizing lines of traffic, in a few great seaports. The modern tendency is for the larger ports and larger cities to become relatively, as well as actually larger. This accounts for the enormous prestige of a few great seaports, and the relative deterioration of many of the smaller ones.

This tendency is best illustrated by the marvelous development of the City of New York, which is now the leading seaport of the world. This development has occurred in the newest of the great world powers, where it has been subjected freely, to the influence of railroad development, which in America is more general than anywhere else in the world. In most of the older European nations, the ocean trade is diffused among a large number of seaports, while in this country over one-third of the total volume of foreign commerce passes through the single port of New York. This tendency has been outlined to show the influences which are at work, to concentrate ocean trade which may develop in the future, to the single points best adapted to receive it. There are those who believe that the San Francisco Bay region is destined

to become one of the great commercial centers and one of the greatest seaports of the world, because if it is once able to dominate the Oriental trade, it should get practically all of it. It is conceded that there are possibilities in the development of commerce with the Orient, which as yet have been scarcely touched and that these are apt to be awakened by the approaching completion of the Panama Canal.

The San Francisco Bay ports have at present but one formidable rival on the Western American coast. The trade between the Orient and the Pacific Slope states will eventually go either to the San Francisco Bay, or to the Puget Sound ports. The tendency is against it being divided between the two. If the San Francisco Bay ports assume the lead in the next two years, they should go farther and farther ahead, until they monopolize practically all of the trade.

The universal experience of the foreign ports, shows that to attract and retain trade, where subject to the competition of rival ports, necessitates the construction of harbor improvements such as wharves and docks, some what in advance of the actual necessities. This law has been abundantly demonstrated by experience. London's commerce has been stationary for several years since the expansion of her docks has lagged. Manchester's commerce has taken an upward trend since her dockage space has been increased at heavy expense. The rate of commercial growth of Antwerp and Liverpool has been greatly accelerated since the costly improvements made about the year 1900. New York has kept up a steady growth in commerce, and terminal facilities. The commerce of the San Francisco Bay ports has not developed as rapidly as it should have and the foreign commerce has been almost stationary. It would seem that a partial explanation is because the construction of wharves and docks, instead of keeping ahead of the actual needs has lagged considerably behind.

CHAPTER II

ADVANTAGEOUS LOCATION OF SAN FRANCISCO BAY FOR HARBOR DEVELOPMENT.

The San Francisco Bay region has the largest population and is the leading seaport on the western coast of the American continent. It is situated near the center of the western coast of the United States of America and at the focus of the principal lines

of ocean and rail traffic. Its advantages for seaport development will be discussed in the order suggested in Chapter I.

Tributary Land Territory (See Plate 1—Map of Central California.)

Immediately tributary to San Francisco Bay by lines of rail and by the two principal navigable rivers of California lie the great interior valleys of the Sacramento and San Joaquin, and the numerous smaller valleys of the Coast Range.

The two navigable rivers emptying into San Francisco Bay are as good, from the standpoint of navigation, as any in this country and relatively as much used. They traverse great valleys whose rapid development is alone sufficient to make a city far greater than San Francisco.

This is a region whose development is still in its infancy. Climatic conditions combine with soil of exceptional fertility, to make it potentially one of the most productive regions of the world. The reclamation of the low lying swamp lands by drainage and flood control, and of the higher plains by irrigation, has just fairly started. Within the next three years, the area of tillable overflow land will be practically doubled. In recent years the greatest check to agricultural development has been the lack of cheap labor. This condition will be immediately relieved when the opening of the Panama Canal brings European immigrants direct to California. The great interior valleys, with an area of approximately 158,000 square miles, support at present a population of only 800,000. With future development they might support twenty millions, and when this condition has been reached, the San Francisco Bay region should have one of the great cities and particularly one of the greatest seaports in the world.

In addition to the development of the territory immediately adjacent, the San Francisco Bay region forms a normal western outlet for the mineral products of the Rocky and Sierra Nevada Mountains, with the agricultural products of the Mississippi Valley and the great Western Plateau and the manufacturing exports of the Eastern and Middle Western cities of the United States.

The radiating lines of transcontinental railroads make the area tributary to San Francisco Bay extend far eastward through the intermountain states down into the Mississippi Valley till into the zone of influence of the Port of New Orleans. This latter is substantially served at present by rail alone, as river traffic on the

NOTE.—The ideas contained in this chapter are taken largely from a report made in 1908 by Luther Wagoner and Col. W. H. Heuer on "San Francisco Harbor; Its Commerce and Docks, with a Complete Plan for Development."

lower Mississippi has declined to a point where it is now negligible.
The vast intermountain region, now very sparsely settled, is much
of it capable of intensive cultivation and is being rapidly developed
under the stimulus of government and private irrigation projects,
ocean routes through lines of railroads leading to the port which
is most highly improved.
and is probably also capable of still further development by means
of arid farming under scientific methods. When developed, it will
furnish an enormous amount of trade, which should reach the

Trade Routes. (See Plate 1, Central California, its relation to cer-
tain Trade Routes and the Panama Canal.)

San Francisco Bay forms the most central and the most con-
venient distributing point in the Western Hemisphere for trade
routes of the Pacific Ocean. This is the greatest of the oceans and
is surrounded by the most thickly settled countries in the world.
The latent possibilities of enormous Oriental trade are being awak-
ened by changing political conditions opening up new markets. It
is certain that the opening of the Panama Canal will afford a
new and important stimulus to Oriental trade.

The opening of the Panama Canal will probably have a more
far reaching effect upon the readjustment of trade than any other
single event in the world's history. The western cities of America,
especially the San Francisco Bay ports are in a position to profit
most by this readjustment. Lines of trade extending from the
Panama Canal to principal Oriental ports will pass within so short
a distance of San Francisco Bay that the latter should generally
be a port of call and a fuel and supply station for through traffic.
The following table gives the shortest distance from the Panama
Canal direct to the principal Oriental ports, together with the dis-
tances to the same points via San Francisco Bay, and the actual
and percentage increase.

There are also given for comparative purposes similar distances by way of Seattle:

Table No. 1—San Francisco Bay, a Port of Call on the Panama Canal Route

Distance in Nautical Miles, which are reckoned at 6080 ft.

Panama Canal to	Shortest Route Miles	Distance via S. F. Miles	Inc. Dist. via S. F.	Miles Percentage	Distance via Seattle
Yokohama......	7650	7798	148	1.9	8315
Shanghai.......	8672	8768	96	1.1	9263
Hong Kong.....	9173	9318	145	1.6	9835
Manila.........	9393	9500	107	1.1	10016
Honolulu.......	4665	5336	671	14.4	6454

The following table gives the distance from Hong Kong and Yokohama to the principal seaports of the United States via the Panama Canal and via the Suez Canal.

Table No. 2—Comparative Distances via Panama Canal and Suez Canal Routes. (In Nautical Miles.)

	TO HONG KONG		TO YOKOHAMA	
	Via Panama Canal	Via Suez Canal	Via Panama Canal	Via Suez Canal
New Orleans........	10608	12924	9143	14386
Galveston............	10879	13124	9247	14586
New York..........	11150	11580	9686	13043

The following is a table showing present distances by water from the Golden Gate to typical foreign ports, with distances via Panama Canal.

Table No. 3—Distances from Golden Gate via Panama Canal and Straits of Magellan Routes. (In Nautical Miles.)

	FROM GOLDEN GATE		SHORTENING	
	Via Straits of Magellan	Via Panama Canal	Miles	Percentage
New Orleans....	13551	4683	8868	65.5
New York......	13135	5262	7873	59.9
Liverpool.......	13517	7830	5687	42.1
Rio Janeiro.....	8612	7447	1165	13.5

A study of tables 1, 2 and 3 indicates in a striking manner the benefits which the Panama Canal should be to the San Francisco Bay ports.

Table No. 2 shows how much closer by water the Panama the Atlantic seaboard, to Oriental ports should use the Panama Canal in preference to the Suez Canal.

Table No. 1 shows that any ships passing through the Panama Canal and bound for the principal Oriental ports can touch at San Francisco Bay without appreciably lengthening their voyage, although in order to reach Puget Sound, San Francisco Bay's chief competitor, they would have to go 500 to 600 miles out of their course.

Table No. 3 shows how much closer by water the Panama Canal brings San Francisco Bay to the principal ports on the Atlantic seaboard, and in Europe.

Local Lines of Communication.

San Francisco Bay is the focal point of the three main transcontinental railroad lines of the Southern Pacific and of the lines of the Santa Fe and Western Pacific, as well as other roads which are making efforts to reach the same point. California has just entered upon an era of electric railway and highway development, leading to San Francisco Bay, which will afford still further possibilities of accelerating development.

Natural Advantages of Harbor.   (See Plate 2)

With regard to the second attribute of a great seaport, the natural advantages of the harbor, it is generally conceded that San Francisco Bay is the finest harbor in North America, and one of the three finest in the world. Most of the great European ports have been developed at enormous expense, along the banks of relatively shallow streams or estuaries, and are approached by narrow and crowded channels.

The entrance to San Francisco Bay through the Golden Gate is deep, wide, and straight, and easily passable. The channel is about three miles long and one mile wide at its narrowest point and from 100 to over 300 feet in depth. About five miles off the entrance is a semi-circular bar with a least depth in the main central channel of about 33 feet at low tide. Along the north shore is the Bonita Channel with a minimum width of a third of a mile and a

low water depth of about 45 feet, and along the south shore, the South Channel with the same minimum width and a depth of about 38 feet. No matter what the size of the ship of the future, it can always easily and safely enter into the Golden Gate and find safe and commodious deep water anchorage within. So easy is the entrance that even the largest steamers pass through it freely without the assistance of tugs.

Probably San Francisco Bay's greatest advantage comes from the very small tidal range, which normally does not exceed 5 or 6 feet, as compared with a tidal range of 20 or 30 feet in the principal European ports. Where the range is so great it has been necessary to provide berth room by the construction of interior basins or docks at enormous expense. The inconvenience, uncertainty and delay of operation is also a serious handicap, as it may be impossible to enter or leave such docks except at high tide.

San Francisco Bay is one of the few places in the world where it is possible to obtain berthing for ships by the exceedingly simple process of building piers and wharves normal to the shore line and directly out into deep water. Relatively inexpensive berth room can also be provided by dredging short channels from deep water into the shore line, or by constructing quay walls in water of moderate depth; dredging the material from in front of the quay walls to the maximum depth required, and depositing the dredged material behind the quay walls to reclaim terminal property.

San Francisco Bay enjoys a mild, invigorating and equable climate. The port is open at all seasons of the year and there are seldom storms of such violence as to prevent ready entrance or egress at any time, while within the bay there is always ample anchorage for ships of any size.

Inadequacy of Present Improvements.

It has been shown that San Francisco Bay has a vast and rapidly growing tributary commercial area and that the natural advantages of the harbor are superior to those of almost any other port in the world.

It must be finally evident then, that the future supremacy of the San Francisco Bay region as a Pacific Ocean seaport will depend upon the third factor—the development of means for rapidly and conveniently loading and unloading freight; and that this development can be made much more quickly and cheaply here, than in most foreign ports.

It has been proven that to facilitate the most rapid possible commercial development requires construction of terminal facilities in advance of actual present necessity.

A study of San Francisco Harbor shows that this condition has not been obtained but that wharf construction has lagged behind the actual needs until the San Francisco wharves are congested to the extent of about 35 per cent in excess of the normal, as shown by general averages elsewhere.*

This means that in order to reduce this congestion to the normal amount, 35 per cent more berth room should be immediately available. It seems certain that the facilities of the San Francisco waterfront will remain inadequate for many years to come. No development which San Francisco could make would preclude the economic development of harbor works at other points on San Francisco Bay where the water front was bordered with property well adapted to industrial improvements and held at a lower valuation than that back of the San Francisco docks, as well as provided with more direct railway transportation. All of the docks which are being constructed along the San Francisco water front will scarcely care for the ordinary increase in trade, and will not remove the congestion above indicated, and of course make no provision for the great additional increase anticipated by the opening of the Panama Canal. If San Francisco has now failed and will continue to fail, to provide adequate docking facilities, it must then be evident that there is both opportunity and necessity for supplementing San Francisco's development by other terminal and harbor work in San Francisco Bay.

CHAPTER III

COMMERCIAL HISTORY OF SAN FRANCISCO BAY.

The whole of San Francisco Bay, with all of its tributary commerce is included in one port in the United States customs department. San Francisco is the only port of entry and Oakland the only sub-port on the bay. All foreign commerce is classed under the port of San Francisco, although much of it is handled at Oakland and Richmond. San Francisco and the other bay cities

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*The Wagoner-Heuer report on San Francisco Harbor, p. 22, estimates that the San Francisco wharves receive 843,000 tons of freight per annum per mile of berth room, where the average of nineteen foreign ports is only 630,000 tons, or 35 per cent less.

are still very young, and during the brief period of their development there have been important changes in their commerce, following in general, marked changes in the industrial development of the state. Prior to the discovery of gold in California about 1848, San Francisco was the only point of importance on the bay. In the years which followed, the Sacramento and San Joaquin Rivers, which were then much more easily navigated than now, carried a large traffic to Sacramento and Stockton, the distributing centers for the mining region. After this came an era of agricultural development, characterized chiefly by the raising of wheat and grain. Port Costa, on the Straits of Carquinez, the deep water port which was farthest inland, became a very important place for storing grain, and shipping it to foreign ports. Shortly after the Central Pacific came to Oakland and located its Pacific terminal there in 1872, appropriation for the improvement of her harbor, by the United States government, started development there. In the early '90s, the relative importance of Sacramento and Stockton showed a temporary decline. There are a number of reasons for this, among which are the deterioration of the navigable river channels from the deposition of mining debris, the cessation by law of hydraulic mining; the rapid decline in the export of wheat, due chiefly to the temporary depletion of the soil and the lessened yield per acre; and finally the development of railroads, terminating at the larger seaports of the San Francisco Bay region. The decline in wheat export has left Port Costa of little importance as a shipping point, though it still supports a few small factories and lumber yards. In the year 1900 the selection of Point Richmond as the main line terminal of the Santa Fe Railroad started the development of that place as a commercial and manufacturing city and was immediately following with harbor improvements by private enterprise.

Since 1900 Oakland and Richmond have grown rapidly until now they rank second and third, as San Francisco Bay shipping points. Sacramento and Stockton have changed little since 1890 in volume of exports, and hence relatively have fallen behind, although the last four years seem to show marked gains. The character of the river traffic has materially changed, however, the bulk of the outgoing shipments now being fruit and vegetables instead of grains. These are commodities yielding a much greater freight tonnage per acre, so that the rapidly expanding volume of river traffic, promises an important revival in the commercial importance

of Sacramento and Stockton. Table No. 4 shows in a general way the commercial growth of some of the ports described above.

Table No. 4—Statistics of Water Borne Commerce in San Francisco Bay.

| Year | SHIP TONNAGE | | FREIGHT TONNAGE | | | |
	San Francisco*	Oakland†	San Francisco	Oakland‡	Sacramento River§	San Joaquin River§
1850	....	....	......	....	....	......	......
1860	....	....	......	....	....	......	......
1870	....	....	......	....	....	......	......
1874	....	....	70,750	....	154,300	......	......
1878	....	....	109,125	....	340,627	167,000	......
1879	....	....	......	....	....	200,925	......
1880	....	....	......	....	....	201,000	230,324
1881	....	....	129,714	....	1,225,226	......	......
1882	....	....	144,004	....	1,407,993	......	......
1883	....	....	143,886	......	1,355,747	......	......
1884	....	....	163,553	......	1,457,968	......	......
1885	....	....	200,226	......	1,744,571	......	......
1886	....	....	188,974	......	1,751,974	......	......
1887	....	1,941,419	130,912	....	1,886,311	......	......
1888	....	2,253,583	162,957	....	2,172,567	......	......
1889	....	2,247,684	185,356	....	2,093,370	......	......
1890	....	2,336,975	213,971	....	2,519,429	249,105	370,000
1891	....	2,378,031	232,706	....	2,697,004	353,056	527,584
1892	....	2,626,328	223,148	....	2,645,181	579,574	395,000
1893	....	2,461,766	195,090	....	2,449,325	466,343	346,094
1894	....	2,341,460	175,750	....	2,428,617	358,014	295,651
1895	....	2,392,284	200,070	3,729,387	2,438,696	419,647	401,684
1896	....	2,546,638	208,155	3,848,461	2,497,589	363,653	431,736
1897	....	2,513,757	256,326	3,657,219	2,623,831	422,111	454,955
1898	....	2,474,749	288,787	3,894,362	2,789,395	394,675	287,524
1899	....	2,581,858	222,764	4,154,453	3,254,215	484,806	270,012
1900	....	2,855,386	313,523	4,646,157	3,600,508	461,314	248,887
1901	....	3,178,828	......	5,048,831	3,770,663	452,965	357,746
1902	....	3,160,314	......	4,890,679	3,830,719	404,900	322,000
1903	....	3,094,036	......	5,203,485	4,237,855	353,724	376,883
1904	....	3,224,491	......	5,528,048	4,708,682	353,164	360,486
1905	....	3,406,469	......	5,292,113	5,248,301	365,957	373,180
1906	....	3,664,649	......	5,748,992	4,410,000	375,000	440,300
1907	....	4,358,648	......	6,802,793	4,210,125	400,000	750,000
1908	....	4,559,737	......	6,468,527	3,600,005	......	......
1909	....	4,689,238	......	6,325,078	4,039,468	......	773,945
1910	....	5,256,970	1,647,875	6,860,148	3,575,371	......	631,681
1911	....	6,135,276	1,250,964	....	....	......	......

It should be noted in studying this table and other similar ones in this report that a "freight ton" is a measure of weight and

NOTE.—A partial compilation for Richmond for the year 1911, including only the Santa Fe and Standard Oil companies' wharves, shows a total freight tonnage of about 2,1000,000 tons.

*Annual Report of Merchants Exchange, 1910-11 (includes all commerce passing through Golden Gate.)

†Annual Reports of Chief Engineers of U. S. Army.

‡Freight passing through jetty channel—including vessels and ferries.

§Includes only freight handled by regular vessels having fixed run.

Other figures from annual reports of Chief Engineers U. S. Army and reports of State Board of Harbor Commissioners for 1910.

is either a "short" ton of 2000 lbs. or a "long" ton of 2240 lbs., while a "ship ton" is an arbitrary measure of volume equal to 100 cubic feet. There is no general relation between the two units. For a further discussion on this subject see Appendix No. III.

The results of Table No. 4 are also shown in graphical form in Diagram No. 1.

CHAPTER IV.

PRESENT AND FUTURE COMMERCIAL DEVELOPMENT OF SAN FRANCISCO BAY.

By far the greater part of the harbor development work in San Francisco Bay has been along a limited portion of the San Francisco water front. There has also been important development in the Oakland inner harbor (San Antonio Estuary) and in more recent years at the Oakland long wharf and the Richmond wharves. Other places in which there have been minor developments are Vallejo, Port Costa, Benicia, Crockett, Sausalito, California City, Alameda, South San Francisco, Redwood City and Alviso.

San Francisco Harbor Proper.

The San Francisco harbor proper, is the bay shore line of San Francisco County and has a total water frontage of about 10 miles. The improved or productive portion extends from the United States Army transport docks at the foot of Laguna street on the north, around the easterly water front to the Western Pacific freight ferry slip, at the foot of Twenty-Fifth street. Along the pierhead line, this is 4.1 miles in length. Along the present bulkhead line (not on the official line, but following the indentations, such as Channel Street and Central basin) the length is 4.95 miles. The development in general has consisted of the construction of piers with their axes normal to the bulkhead line, separated by slips wide enough for two vessels. Where piers have been constructed, a concrete or rock seawall has usually been finished up to the bulkhead line, and the slips have been dredged to a depth of 30 feet to 33 feet, the normal depth of water along the bulkhead line being 16 feet to 24 feet. According to the Wagoner-Heuer report, in 1907 there were 1.8 miles of water front which had been thus developed with piers and slips, and in such a way that for each linear foot of natural water front there was

provided a berthage of 4.6 feet or a total for 1.8 miles of fully developed frontage, of 8.3 miles of berth room.

With the exception of the wharves of the Union Iron Works, the Western Sugar Refinery and the United States Government docks at Ft. Mason, the whole improved water front belongs to the State of California and is administered by the State Board of Harbor Commissioners. Financially, the port has always been self-supporting. Revenues are derived from dockage, wharf tolls, wharfage, wharf rental and building and land rentals. Small bond issues have been sold occasionally for the execution of needed improvements and extensions. All expenses of operation and maintenance of the port, and interest and sinking funds for bond issues are met by the port charges. This is an obnormal condition and in spite of great natural advantages has resulted in producing port charges, somewhat higher than the average elsewhere, because of the excessive cost of labor for stevedoring. It is more usual to have a substantial portion of the first cost of harbor improvements borne by the community as a whole because of the general stimulus to commerce and business. The congestion of the San Francisco docks at the present time results in much complaint from shippers and merchants, and constant efforts are made on the part of the wharf officials, to secure more rapid removal of freight.

A state bond issue of $9,000,000 became available this year for harbor improvements and important contracts have recently been awarded for the construction of new concrete and steel piers. The greater part of this b ond issue will probably be used in extending improvements a long the southerly water front. State bonds to the value of $12,000,000 for the improvement of the harbor have been authorized in three issues: $2,000,000 has been sold, $9,000,000 will soon be sold, and $1,000,000 is held up by litigation. A popular agitation is under way looking toward the transfer of the water front from state to city control. If this is accomplished it may result in a more general aggressive policy of municipal support for the harbor.

The only railroad having direct access into San Francisco is the Southern Pacific line down the Peninsula. Other railroads generally transfer freight by car-floats. Three transcontinental railroads, the Southern Pacific, Western Pacific and Santa Fe have freight terminals along the water front. The Northwestern Pacific also has a freight slip at the foot of Lombard Street. The Northerly portion of the San Francisco water front is served by a state owned belt line railroad, and part of the southern portion has re-

cently been equipped with belt connections. It is planned to ultimately have belt railroads, serve the entire water front, passing beneath an overhead passenger construction at the foot of Market Street. The principal passenger terminal in the city is the Union depot and ferry building at the foot of Market Street. The Southern Pacific also has a passenger station at Third and Townsend Streets.

Oakland Harbor.

Although the San Francisco water front receives the bulk of the water-borne commerce, yet Oakland, with its wharves on the estuary, the long wharf of the Southern Pacific and the new sea-wall in the Key Route Basin and quay wall along the estuary, is rapidly gaining the position of a serious competitor. She has the advantage of direct accessibility to three transcontinental railroads, and two interurban electric lines, and of having large, level areas, well adapted to industrial, or residential development. On the other hand, harbor development has been greatly handicapped by the long reaches of shallow water offshore. The principal development has been in the inner harbor along the estuary, where the government has constructed training walls, an inner basin, a tidal canal, etc. Fronting these are various private and public wharves, such as the Alaska Packers' Association, the Adams and City of Oakland wharves. The outer harbor at present consists of five long railroad piers, three of the Southern Pacific, and one each of the Western Pacific and Key Route. The Key Route pier and two of the Southern Pacific piers are principally for the transfer of passengers.

The City of Oakland recently gained control of a large part of her water front, mostly in the outer harbor, and is proceeding with a comprehensive plan for its development. Concrete quay walls have been constructed in the inner harbor at the foot of Livingstone Street, and a long, rock fill, sea wall is under construction in the outer harbor, in the Key Route Basin. A project is also under consideration for the construction of a subway underneath the estuary in order to eliminate the troublesome drawbridges, which must now be passed before entering the inner harbor. The United States Government is engaged in an extensive project for dredging the estuary and the inner harbor to a low water depth of 30 feet and with a 500 foot width. This project also includes a channel to be constructed around the tidal basin, 25 feet deep and 300 feet wide, and the dredging of the tidal canal to 18

feet in depth. When completed this channel will have a total length in the harbor of 7⅛ miles, and in the tidal canal of 2¾ miles. The estimated cost is $1,000,000, with a yearly expenditure of $25,000 for maintenance. The railroad freight terminals and shops of the Southern Pacific and Western Pacific are located near the land end of the training wall channel at the foot of Kirkham Street. The Oakland Santa Fe terminal is at Fortieth Street and San Pablo Avenue, near the northeasterly corner of the new outer harbor. The expenditure of a recent bond issue of $2,500,000 for harbor development purposes will place Oakland in a position to actively compete with San Francisco.

Richmond.

Richmond has natural advantages which in many ways surpass those of any other port on San Francisco Bay. Deep water is closer to the shore line than anywhere else on the east side. The main Santa Fe terminal and the main line of the Southern Pacific go through the city. There is a large area of level land for industrial development. Already there are located at this point a number of very large manufacturing concerns, such as the Standard Oil Company, Santa Fe car shops and Pullman car shops. Heretofore the traffic has been handled by private wharves, and to a small extent by the public wharves controlled by the Santa Fe and the Richmond Belt Line Railroads. A number of pretentious projects are being actively promoted at the present time, for the development and control of the Richmond waterfront under public ownership. These will undoubtedly mature in the near future and will divert an important portion of the San Francisco Bay commerce to Richmond.

Berkeley Water Front.

The City of Berkeley has a new and modern timber wharf on concrete and wooden piles extending about 4,000 feet from shore and terminating in water with adepth of 17 feet at high tide. This is located at the foot of University Avenue, about midway between Oakland and Richmond.

Vallejo.

Vallejo is a thriving city of 12,000 population and has considerable terminal business. The Mare Island Navy Yard is the largest navy yard on the Pacific Coast, with several thousand feet of wharf and two dry docks, and employs over three thousand men. Opposite the Mare Island Navy Yard on the Vallejo water front, are

DIAGRAM No 1
SAN FRANCISCO BAY HARBOR STUDIES
GRAPHICAL REPRESENTATION
OF
SHIP AND FREIGHT TONNAGE MOVEMENT
1874 TO 1911

SEPT. 1912   HAVILAND & TIBBETTS
CIVIL ENGINEERS
SAN FRANCISCO.
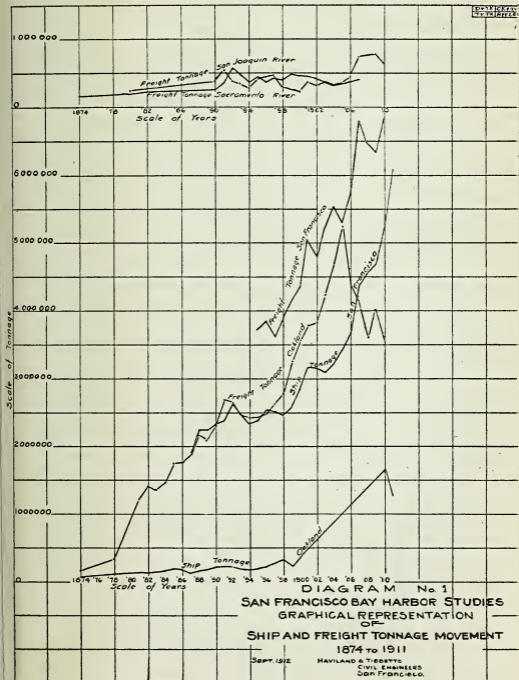
the terminal wharves of branch lines of the Southern Pacific, of the Napa Valley Electric Railroad, the Vallejo & Northern Electric Railroad, and the Sperry Flour Mills.

Minor Bay Terminals.

Among the minor bay terminals deserving of mention are those on the southeast shore of San Pablo Bay and the Straits of Carquinez, including wharves of the California Sugar Refinery Company, and the Port Costa Lumber Company.

There are several lumber yards and manufacturing plants with wharves at Martinez and Bay Point. On the north shore are small terminal wharves at Sausalito and the naval coaling station at California City. Some of the places recently opened by Government and other improvements, for light draft bay craft, are Redwood City, Petaluma, Alviso and Suisun.

Volume of Water-Borne Commerce.

Efforts have been made to estimate the total freight tonnage and total ship tonnage passing through the Golden Gate, and to segregate this in order to determine the portion of it which is handled along the San Francisco water front, the portion at the Oakland wharves and estuary, and the portion at the remaining bay ports.

Available data is so fragmentary and conflicting that many of of the figures are subject to great uncertainty. The information in general has been compiled from the annual reports of the San Francisco Merchants Exchange, the annual reports of the Chief of Engineers, U. S. A., and the biennial reports of the State Board of Harbor Commissioners, together with incidental data from various sources. Reliable data is given for the total ship tonnage through the Golden Gate and for the total freight tonnage handled over the state wharves at San Francisco. Practically all other data has been estimated in whole or in part, either in the preparation of this report or in the sources from which it was derived, or both.

Freight Tonnage.

Table No. 4 and Diagram No. 1, Page 33 gives statistics for freight and ship tonnage for Oakland and San Francisco.

Table No. 5 and Diagram No. 2 show the estimated freight tonnage passing through the Golden Gate segregated under three headings, 1st—handled over San Francisco wharves; 2nd—handled at Oakland, and 3rd—handled at remaining San Francisco Bay ports.

Table No. 5—Forecast of Probable Future Freight Tonnage, San Francisco Bay Ports.

Year	Total	San Francisco	Oakland	Other Points
1910	5,861,000	2,635,000	1,757,000	1,465,000
1915	7,560,000	3,400,000	2,270,000	1,890,000
1920	9,370,000	4,220,000	2,810,000	2,340,000
1925	11,580,000	5,220,000	3,470,000	2,890,000
1930	14,380,000	6,470,000	4,315,000	3,595,000

The freight tonnage over the San Francisco wharves is estimated from tables of the port revenues on the basis of 5 cents per ton, wharf tolls. Table No. 4 shows that the mean rate of growth of the San Francisco freight tonnage since 1890 has been 4.39 per cent per annum. This same rate was adopted to forecast the future freight tonnage growth for all segregations made in Table No. 5. Estimates made for 1910 show that the total freight tonnage passing through the Golden Gate, approximately 45 per cent was handled over the San Francisco wharves, 30 per cent at Oakland, and 25 per cent at the remaining bay ports. For forecasting for the future it was estimated that those same percentages would continue. No attempts have been made to segregate the tonnage distributed among bay cities other than San Francisco and Oakland, as reliable data for other points is wholly lacking.

Ship Tonnage.

Table No. 6 and Diagram No. 3 indicate the total ship tonnage passing through the Golden Gate; segregated as has been the freight tonnage, for San Francisco, Oakland and the remaining bay ports.

Table No. 6—Forecast of Probable Future Ship Tonnage of San Francisco Bay Ports.

Year	Total	San Francisco	Oakland	Other Points
1910	10,563,104	7,636,000	2,126,208	736,600
1915	16,400,000	11,480,000	3,280,000	1,640,000
1920	23,200,000	16,240,000	4,640,000	2,320,000
1925	32,900,000	22,400,000	6,400,000	3,200,000
1930	47,100,000	32,900,000	9,420,000	4,710,000

The 1911 report of the San Francisco Merchants Exchange, page 34, estimates the total ship tonnage entering and leaving through the Golden Gate at 10,563,104 tons. The biennial report of the Board of State Harbor Commissioners, page 117, estimates the total ship tonnage docked at the San Francisco wharves at

Scale of Freight Tonnage

16000000

15000000

Note
The curve giving probable future Total
Tonnage for San Francisco wharves from all
Sources is forecasted of a 4.393 annual
increase. The mean rate of growth from
1900 to 1910
All other curves are projected ahead
of the same rate of increase.

14000000

13000000

12000000

11000000

10000000

9000000

8000000

7000000

6000000

5000000

4000000

3000000

2000000

1000000

Total Tonnage for San Francisco Wharves from all Sources

Total Tonnage passing thru the Golden Gate

Tonnage thru Golden Gate and over San Francisco Wharves

Tonnage thru Golden Gate and over Oakland Wharves

Tonnage thru Golden Gate and over all other Wharves

DIAGRAM No 2

SAN FRANCISCO BAY HARBOR STUDIES

GRAPHICAL REPRESENTATION
OF
PAST AND PROBABLE FUTURE

FREIGHT TONNAGE MOVEMENT

SEPT 1912   HAVILAND & TIBBETTS
CIVIL ENGINEERS
San Francisco.

1894   1898   1902   1906   1910   1914   1918   1922   1926   1930
Scale of Years

7,636,000 tons or 72 per cent of the total given above. It is estimated from the best data available, that of the remaining 2,887,-940 tons, 2,000,000 tons or 19 per cent of the total passing through the Golden Gate was docked at Oakland, and the balance of 9 per cent of the total, was distributed among the other bay ports, principally Richmond, Crockett and Port Costa. For simplicity is assumed in round numbers in forecasting ship tonnage in Table No. 6 that of the total passing through the Golden Gate, 70 per cent will be handled at San Francisco, 20 per cent at Oakland and 10 per cent at the remaining bay ports.

The total ship tonnage movement through the Golden Gate has increased during the last decade 85 per cent or at a yearly date of 7.35 per cent. It is estimated in forecasting the future ship tonnage that this same rate will be maintained for all segregations as well as for the total.

Probable Future Commerce.

Predictions from past records, of probable future commerce are dependable in no small degree upon the optimism of the engineer making the computations. Ocean-borne commerce tends to crystalize at the larger ports. If San Francisco Bay is able to monopolize Pacific Ocean trade in the same way that New York has been able to monopolize the Atlantic Ocean trade, then its rate of growth will be vastly accelerated, and greatly exceed its past rate. Because of the great importance of the new condition (the Panama Canal) in stimulating Oriental commerce and in bringing it close to the San Francisco Bay ports it seems unwise to predict very far in advance. The diagrams and tables given above, of future growth, however, have ignored such features and are based upon the indicated growth in recent years. They should hence form the most conservative possible estimates of future growth and are very apt to be far too small.

The distribution particularly, of the assumed increase in commerce, will depend almost entirely upon future harbor development. The bulk of the freight, and particularly of the ship tonnage entering the Golden Gate has heretofore gone to the San Francisco wharves, because they were the only ones available. If the East Bay ports in the future, provide facilities equal to those of San Francisco they should get an equal share of the commercial increase. If they do not, then the present distribution as shown in the diagram will probably continue.

The increase will come to the wharves most conveniently situated with reference to the entrance to San Francisco harbor, and to inland transportation lines and which are at the same time best prepared to receive it; that is, to those which offer the safest and cheapest facilities for discharging cargo and for temporary storage. The direction in which harbor development will go in San Francisco Bay will depend largely upon the financial support given the various projects. Those communities which are willing to undertake costly improvements well in advance of immediate needs and with little possibility of immediate and direct returns, should find their work very profitable in the end. Even if San Francisco provides abundant and cheap wharf facilities, yet the superior ability of Oakland and Richmond to furnish convenient railroad transportation and ample room and opportunity for industrial expansion will assure their harbor development.

The bay cities which will absorb the bulk of this increase with its corresponding increase in population, wealth and general prosperity, are those which provide in the immediate future, increased wharf and terminal facilities with the minimum port charges and the maximum convenience and rapidity of operation.

Commerce of Other Ports.

For comparative purposes there is shown in Table No. 7, the ship tonnage at the other principal Pacific Coast ports, and a few other typical ports. The table shows clearly that the Puget Sound ports, and to a lesser degree, the Columbia River ports are dangerous competitors of San Francisco Bay ports. This is particularly true, because the former are growing at a more rapid rate, and are receiving better financial support, even though they have not the natural advantages of San Francisco harbor.

Table No. 7—Comparison of Ship Tonnage Movement in Pacific Coast and Other Harbors. (1907.)

Port	No. of Vessels			Vessels' Tonnage		
	Ent.	Cleared	Total	Ent.	Cleared	Total
Puget Sound ports—						
Seattle, Wash........	869	849	1718	1,442,405	1,388,920	2,831,325
Tacoma, Wash........	1715	1676	3391	1,836,555	1,794,322	3,630,877
Olympia, Wash........	36	36	72	36,336	36,336	72,672
New Whatcom, Wash..	226	226	452	106,119	106,119	212,238
Everett, Wash........	219	219	438	197,428	197,428	394,856
Total Puget Sound ports.	3065	3006	6071	3,618,843	3,523,125	7,141,968
Astoria, Oregon—						
Domestic	1279	1243	2527	1,618,447	1,516,342	3,134,789
Foreign	91	115	206	258,855	333,700	592,555
Portland, Ore.—						
Domestic	503	436	939	529,141	389,936	919,077
Foreign	41	104	145	98,402	236,386	334,788
Total Columbia River ports	1914	1903	3817	2,504,845	2,476,364	4,981,209
Coos Bay, Ore.........	79	79	158	24,767	24,767	49,534
Coquille River, Ore.....	25	25	50	5,423	5,423	10,846
Humboldt Bay, Cal.....	1002	1004	2006	475,954	476,903	952,857
S. F. Bay ports—						
Domestic	....	....	....	2,700,435	2,671,889	5,372,324
Foreign	....	....	....	1,166,280	1,037,271	2,203,551
Total S. F. Bay ports..	....	....	....	3,866,715	3,709,160	7,575,875
San Luis Obispo Bay..	236	236	472	194,950	194,950	289,900
The ports of Los Angeles, Cal—						
Domestic	1410	1407	2817	629,592	628,374	1,257,966
Foreign	7	7	14	12,564	12,564	25,128
Total Los Angeles ports	1417	1414	2831	642,156	640,938	1,283,094
San Diego, Cal........	407	411	818	319,440	327,203	646,643

The above is taken from page 331 of Report of the Commissioner of Corporations, on Transportation by Water in the United States, Part II, Water Borne Traffic, July19, 1909.

OTHER TYPICAL PORTS*

Port	Year	Vessel Tonnage
New York (foreign only)........................(1907)		20,458,526
Liverpool ....(1906)		16,000,000
London ....(1906)		17,600,000
Hamburg ....(1906)		10,500,000
Antwerp ....(1906)		11,000,000
Rotterdam ....(1906)		9,300,000

*From Statistical Chart of Wagoner-Heuer Report on San Francisco Harber.

Note.
The curve giving the probable future ship tonnage entering and clearing the Golden Gate is predicted at a 7.25% annual increase. This percentage is the mean rate of growth shown from 1901-1911

The curve for San Francisco represents 70% of the total tonnage
The curve for Oakland represents 20% of the total tonnage
The curve for all other wharves represents 10% of the total tonnage

Total Tonnage Entering and Clearing the Golden Gate

Ship Tonnage docked at San Francisco Wharves

Ship Tonnage docked at Oakland Wharves

Ship Tonnage docked at all other wharves

Scale of Tonnage

48,000,000
44,000,000
40,000,000
36,000,000
32,000,000
28,000,000
24,000,000
20,000,000
16,000,000
12,000,000
8,000,000
4,000,000
0

1830 1834 1838 1902 1906 1910 1914 1918 1922 1926 1930
Scale of Years

DIAGRAM No 3
SAN FRANCISCO BAY HARBOR STUDIES
GRAPHICAL REPRESENTATION
OF
PAST AND PROBABLE FUTURE
SHIP TONNAGE MOVEMENT

SEPT 1912   Hoviland & Tibbetts
Civil Engrs.
San Francisco

PART II

General Description of Richmond

CHAPTER V

TOPOGRAPHY OF RICHMOND AND VICINITY.

General Location.

Richmond is a new city of about 12,000 inhabitants, located on the eastern or northeastern shore of San Francisco Bay. It includes the rocky peninsula separating the main portion of San Francisco Bay from San Pablo Bay, its Northern extension. The city occupies the broadest portion of the narrow plain between the Contra Costa or San Pablo foothills, and the eastern shore of San Francisco Bay. Richmond is the most northern of the chain of cities which on the eastern shore of San Francisco Bay, running from north to south, includes Richmond, Albany, Berkeley, Emeryville, Piedmont, Oakland, Alameda, San Leandro and Hayward. It is in Contra Costa County just north of the Contra Costa-Alameda County boundary line.

The Santa Fe ferry slip at the end of Point Richmond is about 8 miles by water from the foot of Market Street, San Francisco. The center of Richmond is about 11 miles from 14th and Broadway, the business center of Oakland. It is directly across the bay from the suburban towns of Marin County, from which it is separated by the narrow strait connecting San Francisco and San Pablo Bays. The Golden Gate at the entrance to San Francisco Bay is only eight miles to the southwest. The relative location of Richmond and the lines of communication with the other cities and the various centers of population in Central California, can be clearly seen by referring to the map of Central California and of San Francisco Bay and Vicinity. (Plates 1 and 2.) Particular attention is called to the favorable location of Richmond with respect to the Golden Gate, as compared with the other East Shore Bay Cities.

Topographic Features.

The City of Richmond covers a large area, having diversified and unusual topography which may be divided into at least three distinct sections. The westerly section of the city lies upon a long narrow range of steep hills extending along the water front. Immediately back of this is the central section, composed of an extensive marshy zone, extending entirely across the peninsula, and formerly so low that at high tide the Potrero hills were an island.

Back of this marshy land lies the eastern section of the city on a smooth plain rising gently to the foothills of Contra Costa County. Upon this eastern section have occurred the most recent developments in the city's growth. There are two quite distinct centers of population, one in the western, and the other in the eastern section of the city, the two being separated by the marshy, central section. The center of valuation of the city as it existed previous to the 1912 annexation is shown on Plate No. 3, located near the corner of First Street and Macdonald Avenue.

The principal manufacturing and industrial plants within the incorporated city are scattered along the westerly water front, and along the Southern Pacific and Santa Fe Railroads. The Standard Oil refineries, the largest plant in the city, extends from the westerly waterfront over the range of hills nearly across the marsh lands to the residence portion of the city, situated on the plain.

The location of the present city boundry lines is best shown on Plate No. 3, and is also partially indicated on Plate No. 5. The city is surrounded on three sides by water. The boundary lines as shown, go far out into the bay so that slightly more than half of the city's area is submerged; 3923 acres of the submerged portions are tide lands, which have been sold by the state into private ownership. The balance, or 4985 acres, is deep water still in government ownership. This makes a total of submerged land within the city limits of 8,908 acres. The boundary lines on the north and east go through the peninsula in a direction generally parallel to the westerly water front, and about midway between the upper or eastern edge of the marsh, and the western base of the Contra Costa or San Pablo Hills.

There has recently been annexed to the city an area of about 4,160 acres, including the centers of population of Stege and Pullman. Most of this territory is high land, lying to the east and southeast of the old city boundary. The total area of the city is now about 17,500 acres, or 27 1-3 square miles, of which the recent annexation is about 24 per cent. The areas of the three natural divisions as outlined above are as follows:

Potrero or western water front district..1960 acres, 22.9 per cent.
Central marshy district...................2000 acres, 23.3 per cent.
Eastern district—high land, including all
    recent annexation ....4600 acres, 53.7 per cent.
Total land area ....8576 acres, 100 per cent.

The narrow range of hills along the westerly water front of the city was called the "Potrero of San Pablo" in the original Spanish grant. This term has been generally abbreviated to the "Potrero." The axis of this district extends in a northwesterly and southeasterly direction for about 5½ miles, from San Pablo Point on the north to Point Potrero on the south. Its maximum width near the midpoint opposite Point Castro is about 1¼ miles. Its maximum width near the residence portion by the Santa Fe tunnel is about one-quarter of a mile.

Between Point San Pablo and Scofield Avenue at the Standard Oil works the hill crest varies in a series of undulating knolls from 150 feet to 500 feet in elevation. The Scofield Avenue cut is about fifty feet in elevation at its summit. From Scofield Avenue, south to the Santa Fe tunnel site, is the lowest portion of the Potrero district, varying in elevation from 100 to 200 feet. Immediately to the south of the Santa Fe tunnel site, the summit rises to 370 feet; then drops to a pass of 180 feet elevation, then rises again to the point of a "Y" 320 feet high, from which radiate two ridges, one running southeastrly to Point Potrero and the other southwesterly to Point Richmond. The Point Potrero ridge rises to 340 feet, then gradually decends to elevation 110 on the knoll near the point. The Point Richmond ridge varies from 200 feet on its higher summit to 100 feet in two low passes near its outer end. The area south of the Santa Fe tunnel site is unimproved grazing land, except on the northeast slope near the Santa Fe tunnel portal, where there are four, closely built up residence blocks.

The exposed cliffs, cuts, excavations, and the Santa Fe tunnel, show that the material underlying the earth mantel on the hills is a yellow, metamorphic sandstone, soft and badly seamed, and at greater depth a harder sandstone mixed with occasional seams of basalt. The harder rock is extensively quarried by the San Francisco Quarries Company near Point Costro and the Healy-Tibbitts Construction Company at Molate Point. It is used for concrete aggregate, road metal and rock fills. Similar sandstone is found in nearly all parts of the Coast Range of California, and is not shown to be self sustaining either in tunnels or vertical cuts.

On the eastern slope, from Scofield Avenue south to the Santa Fe tunnel, is a well developed residence and business section, comprising the original town of Point Richmond, which was founded soon after the building of the Santa Fe Railroad, whose tide water terminal is on the outer side of the Potrero, opposite. This improved portion is about 1¼ miles in length and covers the full

width of the range of hills, extending southeasterly from the Standard Oil refineries to the Santa Fe Railroad tracks. Along the western edge of the Potrero district, lies the outer water front with a number of warehouses and manufacturing plants.

The area of the Potrero section over which streets have been laid out, is about 303 acres, or about 15½ per cent of the total of 1,960 acres.

Central or Marshy District.

The central, marshy area, covers a strip of land about ¼ to 1½ miles in width and 3 miles in length, containing about 2,000 acres. It is traversed by winding sloughs, and is so low that formerly at high tide it formed an island of the Potrero hills. It was seriously proposed at one time to dredge a tidal canal completely through this marshy area, connecting San Pablo and San Francisco Bays, and isolating the Potrero. A large area near the center of the marsh has recently been filled in and reclaimed, and is used as railroad yards by the Santa Fe and as sites for several very important manufacturing plants. Recently additions have been made to the reclaimed area to provide for further extensions of the Santa Fe Railroad yards. These reclaimed areas connect the Potrero hills with the main developments in the city on the east of the marsh, and divide the marshy area into two quite distinct portions. The northerly portion is the most extensive and is entirely undeveloped, being traversed by a net work of sloughs and overgrown by rice grass, tules and other forms of aquatic vegetation. The southerly portion slopes more rapidly to the water and is traversed by one large winding slough extending inward from Ellis Landing, along the base of the Potrero hills. Private interests have straightened out a portion of this slough and dredged a channel into the marsh, using the excavated material for filling in a portion of the adjacent marsh. The southern edge of this section is the location of the proposed inner harbor developments, which will be constructed in the sheltered cove inside of Point Potrero, Brooks Island and Point Isabel. It occupies a particularly favorable position for ultimate development into a manufacturing, shipping and business district because it will be immediately accessible to the inner harbor, and is already surrounded on land side by developed city property, and by the yards and tracks of the Santa Fe Railroad. Its reclamation can be economically effected by filling it with the material dredged from the inner harbor.

Eastern Portion of City.

The main portion of the present city, including the larger and newer developments, lies immediately east of the center of the marshy area, and is approximately square, occupying the center of the peninsula. The southern portion of the marshy area, which the inner harbor will develop, extends up into the southwest edge of this section. The railroads and street car lines go through it. It is bordered on the north, east and southeast by large areas of plain and foothill land giving plenty of room for future expansion. The outlying sections bordering the city are now being rapidly subdivided and settled, and will sooner or later be annexed to Richmond. The level land is perfectly adapted to business and industrial development, and the foothill land is but a short distance back and will form a choice residence district. This section, with all the recent annexation, now includes 4,600 acres within the city boundaries. In the near future there will probably be annexed to Richmond a considerable additional area of the eastern foothill residence section, and some more level land toward San Pablo. This should add at least 1,000 more population and $2,000,000 of assessed valuation.

CHAPTER VI

RICHMOND WATER FRONT.

Division of Water Front.

The water front of Richmond is naturally divided into three parts as follows:

1st. The San Pablo Bay Frontage, lying to the north of the city and east of San Pablo Bay, consisting generally of shallow water and forming a continuation to the north of the marshy area in the center of the city.

2nd. The Outer Harbor Frontage on the west, at the base of the Potrero hills, between Point San Pablo on the north and Point Potrero on the south.

3rd. The Inner Harbor Frontage on the south, comprising a shallow basin lying between Point Potrero, Brooks Island, Point Isabel, Stege and Ellis Landing.

The lengths of the actual shore line at mean low tide on the three main sections of water frontage are 4.0 miles, 8.0 miles and 6.0 miles, a total of 18.0 miles.

San Pablo Bay Frontage.

The San Pablo Bay frontage at the north, is shallow for about two miles from shore. It faces the most undeveloped portion of Richmond, and is farthest from San Francisco and the Golden Gate, and the lines of railroad and water transportation. Much of this area is capable of reclamation for agricultural or other purposes by the construction of levees.

Outer Harbor Frontage.

The central section along the western base of the Potrero hills forms the site of the present and proposed future outer harbor developments. Deep water is closer to the shore here than at any other point on the eastern edge of San Francisco Bay. At the northern end of Point San Pablo the rocks descend almost vertically into 90 feet of water. Along the greater portion of the Potrero hills, water from 16 to 30 feet in depth is found within 500 feet of the projecting points. Between the points, however, are large areas of water so shallow that 20 to 30 feet in depth can only be reached several thousand feet from shore. This section of water front at the present time has, however, a great disadvantage in being difficult of access from the land side, and in having few suitable building sites along the shore. There are less than one-half dozen flat areas, of a few acres in extent, generally located in small valleys between projecting points where it is most difficult to reach deep water. Access to the improved portion of the city must be obtained by going over or through the range of hills. At the present time, teaming is practically restricted to the Scofield Avenue cut through a very low divide at the Standard Oil works and to the roadway extending around Point Potrero, to the Los Angeles Brick works. For railway traffic there is the double track Santa Fe tunnel, the East Shore and Suburban track through the Scofield Avenue cut and the Richmond Belt Line Railroad, along the inner base of the hills to Point San Pablo.

Southern Water Front.

The southern water front is the site of the proposed inner harbor development. It comprises a shallow basin between Point Potrero, Brooks Island, Point Isabel and the shore, about 1,700 acres in area. The western edge of this basin at Potrero Point and Brooks Island is now 1¾ miles from deep water near Point Richmond. The northern point of the basin at Ellis Landing is only

1½ miles from the center of population of the entire city. From this point an old slough formerly extended along the base of the hills through the marshy zone. Private enterprise has attempted to make an inner harbor by dredging out this slough and filling the adjacent marsh land. This basin forms the site of the so-called inner harbor project of U. S. Army Engineers.

Government Inner Harbor Project.

The essential features of this project are the formation of a tidal basin by the construction of a dike from Brooks Island to Point Isabel, the dredging of a channel to deep water, and the protection of the channel by a training wall on the south side extending from Brooks Island parallel to a line from Point Potrero to Point Richmond. A channel is to be dredged 20 feet deep at low water from deep water near Point Richmond, entering the tidal basin immediately south of Point Potrero. A large basin for shipping is to be dredged near the center of the tidal basin with a branch extending up to Ellis Landing. All channels are to have eventually a minimum width of 600 feet, and depth of at least 24 feet. Assuming this work to be completed, the inner harbor project of Richmond would then start with a channel to be dredged and maintained by government appropriations, extending towards the center of the city, about to Ellis Landing, and including a large dredged ship basin near the center of the tidal basin.

Ownership.

The submerged lands around the entire water frontage originally owned by the State of California, and subdivided into tide land lots, have passed into individual and corporate ownerships. These submerged lands on the San Pablo Bay water front aggregate about 645 acres, on the Potrero water front about 1,153 acres, and on the inner harbor water front, east of Point Potrero and north of the Alameda-Contra Costa County line, about 2,15 acres. The inner boundary of these tide lands is the outer edge of the marsh. The outer boundaries are approximately straight lines between headlands and lie in water from five feet to fifteen feet in depth at low tide.

The appended table No. 8 shows the names of some owners of tide lands and the areas and county assessed valuation of their holdings.

Table No. 3—Ownership, Areas, and Assessed Valuation of Richmond Tide, Swamp and Overflow Lands.

STATE TIDE LANDS			STATE TIDE LANDS.		
Ownership	Acres	Assessed Valuation	Ownership	Acres	Assessed Valuation
On San Pablo Bay—			Inside Point Potrero—		
Allardt	1.62	$ 125	Allardt	6.66	$ 500
Barker, F. C......	3.24	250	Barker, F. C....	13.32	1,000
Bishop, W. H.....	3.24	250	Bay Co. Land Co.	274.81	20,610
Blake, A. S.......	1.62	125	Berkeley Water		
East Shore Co....	129.86	16,230	Front Co.	373.90	27,810
Haley, Percie ...	6.00	750	Bishop, W. H.....	13.32	1,000
Milnes, G. E.....	95.54	4,295	Blake, A. S......	6.66	500
Scanlon, Mrs. P..	401.77	24,100	Ellis & Cutting..	106.05	7,950
			Eschen, J. C....	9.69	725
Western Water Front—			Hodgon, I. O.....	40.00	3,000
Allardt	85.10	17,785	Morfew, M. J....	35.00	2,625
Anglo P. Dev. Co.	100.22	16,425	Neibaum, G.	4.00	300
Barker, F. C.....	170.20	35,570			
Bishop, W. H....	170.20	35,570	SWAMP AND OVERFLOW LAND.		
Blake, A. S.....	851.10	17,785	San Pablo Bay—		
Crook, J. J......	16.17	2,425	McCracken, Wm.	1.60	480
Crook, M. J......	17.55	2,635	Mintzer, Wm. ...	1.50	1,400
Henshaw, Wm. G.	71.58	10,735	Peoples W't'r Co.	168.22	9,835
Hogdon, I. O.....	18.39	2,760	Tewksbury	837.60	134,385
Lake Henry	13.27	2,785	Berkeley Water		
Morfew, M. J. ...	16.26	2,275	Front Co.	39.53	2,965
Nicholl, Jno. ...	38.05	3,705	Ellis & Cutting..	103.00	7,720
San Pablo			Pt. Richmond Canal		
Quarry Co. ...	52.83	10,040	and Land Co...	205.00	22,875
Standard Oil	20.85	5,860			
Santa Fe	140.00	28,000			
West San Pablo					
Water Co.	19.22	1,440			
Unknown Owner.	30.00	3,585			

Some of these ownerships are in undivided interests, the fractions being one-third and one-sixth. Partnership ownerships are given as partnerships.

CHAPTER VII.

RICHMOND HARBOR AND APPROACHES.

Richmond's Position Relative to the Golden Gate.

Richmond's position with reference to the entrance of San Francisco Bay is more favorable for harbor developments than any other city on the eastern side of the bay. On Plate No. 2 are drawn one mile circles, radiating from the center of the Golden Gate at its narrowest point, which is midway between Lime Point and Fort Point.

The distance from the Golden Gate to some well known points in San Francisco Bay are as follows:

Point Richmond .... 7½ miles
Outer edge of Oakland's outer harbor.................. 8½ miles
Hunter's Point, near the southern end of the San Francisco water front .... 8¾ miles
Ellis Landing and the center of the proposed Richmond ship basin 9
Inner end of the Oakland Harbor Training Wall........ 9½ miles
Easterly end of Oakland's Inner Harbor................12¾ miles
Point San Pablo, at the extreme northerly end of the Richmond water front ....10¼ miles

The relatively clear, fair way for the passage of vessels from the Golden Gate to Point Richmond is another advantage as compared with the many ferry tracks and anchorage grounds which interfere with passage to other points in San Francisco Bay.

San Francisco Bay Channels. (See Plate No. 2.)

There are two main channels, leading from the Golden Gate to Richmond. The **northern channel** runs along the Marin County shore, through Raccoon straits, north of Angel Island, and up the bay through the straits opposite Point San Pablo. Southampton Shoal, between the northeastern end of Raccoon Straits, and Point Richmond separates this channel from the Richmond water front. By means of a short detour around the northern end of the shoal a clear route with a minimum depth of 30 feet, can be readily obtained to Richmond's outer water front. The main channel, however, has depths of 43 to 300 feet, so that any desired depth of water could be obtained by dredging around Southampton Shoal. A 20-foot depth of channel can also be obtained through Raccoon Straits and by means of a short southerly detour around the south end of Southampton Shoal, to Point Richmond.

The **southern channel** extends through the central deep portion of San Francisco Bay and connects with the Oakland harbor, and the San Francisco water front. Ships bound for Richmond can go along the southerly shore of Angel Island and connect with the first channel described above, with a 20-foot depth around the southern end, or a 30-foot depth around the northern end of Southampton Shoal. Either of these routes give direct deep water access to the San Francisco water front or the Golden Gate.

The **Southampton Shoal** referred to lies directly in front of the southern portion of the Richmond outer water front. It is about

2½ miles long and from one-quarter to one-half mile in width. The depth of water over the shoal at mean low water varies from 9 to 18 feet. Between this shoal and the Richmond water front, is a secondary channel from 22½ to 30 feet in depth at low tide, connecting with deep water in the main part of the bay immediately south of the light house at the south end of the shoal, and also connecting with the 5 fathom line at the end of the Standard Oil wharf, opposite the northern end of the settled portion of the Potrero district. A 30-foot channel direct to the Richmond water front could be obtained, as will be subsequently shown, by dredging around the south end of Southampton Shoal.

The five fathom, or 30-foot depth, line in San Francisco Bay, runs nearly straight from Yerba Buena or Goat Island opposite the San Francisco water front to San Pablo Point at the northern end of the Richmond water front. It passes immediately west of the Southampton Shoal to a point about one-half mile to the west of the Standard Oil wharf, where it is offset shoreward to within 600 feet of the wharf, and thence it runs immediately west of Castro Rocks direct to Point San Pablo. Along the southern portion of the Richmond water front the five-fathom line keeps outside of the Southampton Shoal, or about two miles from shore; but along the northern portion it runs close up to the shore at the projecting points.

At the present there are two light houses along the Richmond water front, one at the southern end of the Southampton Shoal, and the other, called "The Brothers' Light House," on a small island about one-quarter of a mile off shore at Point San Pablo, and in the narrowest part of the strait, which is only 1¾ miles in width at this point.

Table No. 9 shows the essential data concerning depths and channel conditions opposite the Richmond water front. Similar information for other portions of San Francisco Bay is shown in Table No. 20, Appendix No. 1.

Table No. 9—Channel Conditions Opposite the Richmond Water Front.

DISTANCE FROM SHORE AT LOW WATER TO

Location—	10-ft. depth	15-ft. depth	20-ft. depth	25-ft depth	30-ft. depth	35-ft. depth
Pt. Potrero	5,600	6,500	7,600	13,400	13,500	13,700
Pt. Richmond	....	150	1,660	8,150	8,500	9,000
Santa Fe Tunnel	3,200	4,900	5,300	10,000	10,300	10,700
Standard Oil Wharf	500	2,600	3,000	4,300	4,600	5,000
Point Castro	150	250	420	2,200	2,400	2,500
Cal. W. A. Wharf	1,600	1,700	1,800	2,900	3,430	3,700
Molate Point	250	330	420	660	1,670	2,100
Pt. San Pablo	50	75	100	125	150	250

Location—	Width of 30-ft. Channel	Width of 35-ft. Channel
Pt. Potrero	7,500	7,500
Pt. Richmond	9,000	8,500
Santa Fe Tunnel	9,500	9,150
Standard Oil Wharf	1,660	6,700
Pt. Castro	13,500	11,250
Cal. W. A. Wharf	8,300	7,900
Molate Point	9,500	8,600
Pt. San Pablo	6,500	6,100

United States Government Harbor Lines. (See Plate No. 3.)

The Secretary of War, upon the recommendation of the San Francisco Harbor Line Board of the United States Army Engineering Corps, fixes the limiting lines for harbor improvements in all navigable waters of the bay and tributaries. The bulkhead line limits the extension of solid fill outward from shore, and the pierhead line outside the bulkhead line, is the outer limit for wharves and piers. A system of wharves and piers similar to that of San Francisco, may occupy the zone between the bulkhead and pierhead lines, or enclosed basins similar to those of European ports may be constructed inside the bulkhead lines, leaving the above mentioned zone unoccupied.

The bulkhead and pierhead lines for Richmond's outer harbor coincide at a point at Point San Pablo. Thence the bulkhead line runs southeasterly to Molate Point and Point Richmond in two straight courses. It lies in water from eight feet to sixteen feet in depth at low tide. The pierhead line runs to an angle about 8,000 feet from the bulkhead line opposite the Standard Oil wharf at Point Orient, thence to an angle point at Castro Rocks about 2,300 feet from the bulkhead line, and thence in a straight line to an angle point about 1,760 feet from the bulkhead line, off Point Richmond. It lies in water from eighteen to fifty feet in depth.

Southwesterly from Point Richmond the bulkhead lines run to shore at Point Potrero, lying in water from five to fifteen feet in

depth. The length of the bulkhead line from Point San Pablo to Point Potrero is 5.58 miles.

The **Pierhead Line** continues far off shore to an angle point which is the outer end of the channel to Richmond's proposed inner harbor, thence to the inner end of this channel, at Point Potrero.

East of Point Potrero the harbor lines have recently been extensively modified to coincide with the lines laid down by Lieut. Col. Rees, officer in charge, U. S. Eng. Office, San Francisco, Cal., for the new inner harbor project. As part of this new proposed harbor development, the pierhead lines are parallel, 1,000 feet apart, and equi-distant from a proposed 600-foot channel, the northern edge of which joins Point Richmond, and Point Potrero. East of Point Potrero the pierhead lines extend due east, parallel and 2,200 feet apart, being equi-distant from an 1800-foot channel, slightly over two miles in length through the center of the basin enclosed by Point Potrero, Ellis Landing, Point Isabel and Brooks Island. The bulkhead lines at the sides and end of this main channel, and at the north side of the channel from Point Richmond to Point Potrero, are 600 feet behind the pierhead lines. This channel also has an arm extending northward, from the western point of Point Potrero, about three-quarters of a mile to Ellis Landing. In this channel arm the pierhead and bulkhead lines coincide, are 1,000 feet apart, and are equi-distant from an 1800-foot channel. In general it will be seen that north of Castro Point the pierhead and even the bulkhead lines at projecting points are in deep water. South of Castro Point, however, that is, along all of the water front close to the settled portion of Richmond, it is impossible to construct piers out to a depth of water greater than 20 to 25 feet. The bulkhead line in general is in water not over 10 to 15 feet in depth.

Possible Improvement of Deep Water Channels.

A 30-foot channel could be obtained along the entire outer water front to as far south as Point Richmond by dredging five feet off the bottom from the Standard Oil Company's wharf southward a distance of about 7,000 feet. A 30-foot channel could also be provided to Point Richmond directly from the San Francisco water front and from the Golden Gate south of Angel Island, by dredging about 10 feet off the bottom, from Point Richmond to the south end of Southampton Shoal, a distance of about two miles. This would follow a well defined channel, already 20 feet in depth. There is reason for believing that if once dredged to 30 feet this

channel might maintain itself. It certainly should do so if the channel were protected and the current concentrated by a jetty along its western side, from a point near the south end of Southampton Shoal to a point near the south end of Point Richmond.

Winds and Tidal Currents.

The outer water front of Richmond is in a somewhat exposed position. The **prevailing winds** in San Francisco harbor are from the west and southwest, but very seldom obtain excessive velocity. Their effect on shipping is felt at all points in the bay except in inner harbor basins, or in the sheltered coves among the hills of Marin County. An exact study and analysis of wind conditions for San Francisco is found in appendix No. IV. The diagrams and conclusions contained therein are assumed, in the lack of more immediate data, to apply equally well to Richmond, where no local records have been kept. Winds exceeding 30 miles an hour are comparatively rare. There have been but four times in the last three years in which the velocity reached forty miles an hour. All four of these storms were from the southwest, and nearly all of the high winds are from either the west or southwest, from both of which quarters the outer harbor of Richmond is freely exposed. The effect of these winds is to occasionally cause ships to drag anchor, and to cast small vessels against moorings, or upon the shore. Even along the San Francisco water front it is stated that large ships occasionally have to leave the wharves and anchor in the channel in order to prevent injury during brief periods of high wind. The strong southwest winds also tend to accelerate the silting up of the interior harbor basin, as they stir up silt and mud from the bottom of the wide, shallow reaches of water along the Berkeley water front, and tend to bring it in with incoming waves.

Tidal Currents have a very much stronger effect upon maintaining channels or silting up protected areas, than has wind action. In San Francisco Bay particularly, the sequence of tides is such that the greatest rate of change always comes upon the falling or ebb tide. This gives the ebb tide currents the greatest velocity and hence the greatest scouring capacity. This effect is readily seen by an inspection of Diagram No. 4, showing tidal variation through a typical month. The energy of the ebb tide is also increased by the discharge of the rivers coming through Carquinez straits, particularly when the rivers are in flood. Where the ebb tide can be concentrated in definite channels, the channels are apt to be kept scoured clean and to deepen rather than shoal. It is stated that the tidal

currents at the end of the Standard Oil Company's wharves, occasionally reach such high velocity as to make it desirable to berth ships parallel to this current, which follows the main channel along the outer water front.

DIAGRAM #4

SAN FRANCISCO BAY HARBOR STUDIES

GRAPH OF TIDES

FOR SAN FRANCISCO FOR MARCH 1912

SEPT 1912

Haviland & Tibbetts, Engrs.
San Francisco

Compiled from U.S.C.G Tide Tables
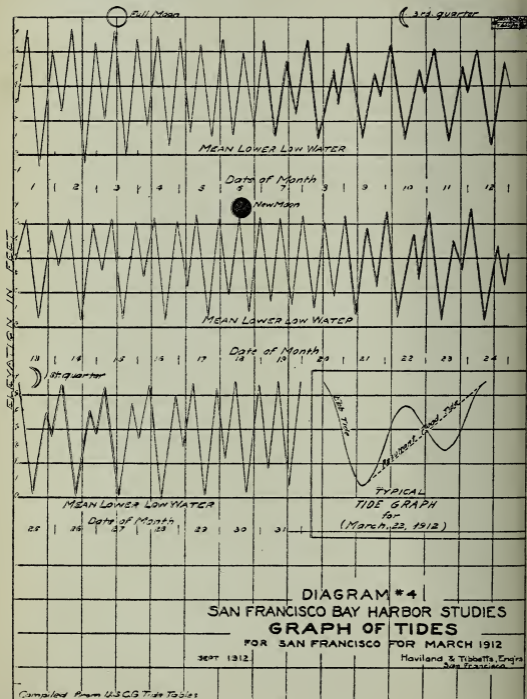
PART III

Commercial Development of Richmond

CHAPTER VIII

INDUSTRIES OF RICHMOND.

Origin of Richmond.

The entire development of the City of Richmond has occurred since 1900. In 1899 the site of the present city was open grazing and farming land. The locality was first developed into a town shortly after its selection as a transcontinental railroad terminal. The Santa Fe Railroad began construction in this vicinity in the year 1899, selecting Richmond as a convenient deep water point on San Francisco Bay. Traffic was first opened through the ferry slip to Point Richmond in the year 1901, giving Richmond exceptional railroad facilities, as the site was already located on the main line of the Southern Pacific, Ogden and Shasta routes. The growth of the city has progressed steadily and rapidly since. The establishment of the Standard Oil refineries in 1902 furnished the second great stimulus to development.

In 1905 Richmond was incorporated as a city of the sixth class and on February 9, 1909, the new charter was ratified by the voters of the city, and on March 4, 1909, was approved by act of the State Legislature giving a modern charter government, as a city of the fifth class.

Richmond owes its original foundation to the opportunity afforded for the construction of wharves and piers reaching out into deep water close to the natural shore line. The exceptional facilities for water and rail communication and the large area of level land, quickly brought to Richmond a large number of industrial concerns, so that the city has now a good claim to an important place in Central California as an industrial and manufacturing community. A conservative estimate places the total investment in 35 of the leading industries at over $25,000,000.00 and the monthly pay roll at over $300,000.00 Among the large concerns worthy of mention are those in the following pages.

Standard Oil Works.

The Standard Oil refineries are the largest in this country west of New Jersey, and on account of their favorable location, and par-

ticularly because of their connection by pipe lines with the great oil fields of the upper San Joaquin Valley, should ultimately be the largest oil refineries in the world. The plant represents an investment of over $5,000,000, chiefly in permanent buildings, and is soon to be enlarged by additional construction, which will increase the capacity of the plant 35 per cent. The plant is complete within itself, being fully equipped for the manufacture of boxes, cans and such other receptacles as may be required for the shipment of its products. The total holdings of the company in this locality aggregate 413.7 acres, most of which is at the narrowest point of the Potrero hills and not far from the geographical center of the city.

A substantial wooden pier 3,500 feet long extends to the pierhead line and ends in water 25 feet deep at low tide. This pier carries several pipe lines to the wharves, at the pierhead line, where large tank steamers are loaded with oil and other products of the works for shipment to important points on the Pacific Coast. There is also a second pier 780 feet long at Point Orient for handling oil in the export trade. Besides the main petroleum refining works, there is a second plant called the Whale Oil Plant, for the handling of whale oil and its products.

California Wine Association.

This industry was located here in 1906 and is now the central storage and shipping plant of the largest grape and wine making company in California, receiving its products from its wineries in all the grape districts of the state. The main cellars, known as Winehaven, is on the outward or western slope of the Potrero hills, toward the northern portion of the city. It includes a large number of substantial brick warehouses and other buildings devoted to wine making and storage. These are contiguous to a pier and large wharf reaching into deep water, from which shipments of California wine are made to all parts of the world. Twelve million gallons of wine pass in and out of Winehaven annually, but there is kept constantly in storage a year's supply of matured wines. Every kind of California wines and brandies are stored here. The holdings of the company aggregate 47 acres and represent an investment of about $1,250,000. This is now being increased by additional permanent improvements.

Pullman Car Shops.

The Pullman car shops are one of the most recent, large industrial establishments to locate in this vicinity. They are located

on a 20-acre tract in the newly annexed portion, immediately south of the main settled part of the city and bordering the Southern Pacific's main line. The company began building this plant in April, 1910, and has expended close to $2,000,000 in permanent improvements. It is the principal plant of the Pullman Company, west of the Mississippi River and is made up of large, modern, fire-proof buildings, well equipped both for manufacturing and repair work.

Santa Fe Railroad.

The main transcontinental line of the Santa Fe Railroad was built to what has now become Point Richmond in the years 1899 to 1901. Ferry boats transfer passengers from Point Richmond to the Union Depot and Ferry Building at the foot of Market Street in San Francisco. Santa Fe cars are transferred on ferry boats and car floats at the foot of Channel Street, San Francisco. A large terminal freight yard is operated near the center of Richmond and is connected by a double track line, passing in a tunnel through the Potrero hills to the piers and slips at Point Richmond, where there are wharves open to the public, as well as private wharves.

Near the center of the city are the extensive car shops and repair plants, employing a large number of men. The holdings of the Santa Fe Railroad Company in Richmond aggregate 459.71 acres, 56.43 acres of which are non-operative property, 360.28 acres operative property and 43 acres right-of-way. The aggregate investment of the Santa Fe in Richmond is very large.

Local Railway Systems.

The Richmond Belt Railway has a wharf at Point San Pablo, at the extreme northern end of the Richmond water front with a thirty foot, low water depth, less than 200 feet from the natural shore line. This wharf is connected by rail around the northeasterly shore of the Potrero district, with the Santa Fe and Southern Pacific Railroads in the center of the manufacturing and business districts of Richmond. The Belt Railway is handling 1,400 freight cars monthly.

The East Shore and Suburban Electric Railway has a line connecting Oakland, Berkeley and Albany with Richmond by way of San Pablo Avenue, and entering Richmond near the Pullman car shops, and traversing the city along Macdonald Avenue. This line extends through Point Richmond and the Standard Oil refineries, to the San Francisco quarry plant and Winehaven on the westerly water front. A branch of the electric car line extends from the

corner of Twenty-Third and Macdonald Avenue to the town of San Pablo, north of Richmond. Another branch line extends along Ohio Street and crosses the city on Sixth Street to the north boundary line. The headway on the East Shore and Suburban Electric car lines between Oakland and Richmond is ten minutes. Richmond is also connected with Oakland by a branch of the Santa Fe Railroad and by the main line of the Southern Pacific. Each of these railways run trains at short intervals through Richmond. The suburban electric systems of the Southern Pacific and of the San Francisco-Oakland Terminal Railways will undoubtedly be extended to Richmond in the near future. The Castro Point Railway and Terminal Company have been granted a franchise from Castro Point to the vicinity of Winehaven and will ultimately be connected with the Belt Line Railway.

The Southern Pacific fast suburban electric service, connecting direct with the San Francisco ferry boats, is now being extended into Richmond.

Los Angeles Pressed Brick Company.

The Los Angeles Pressed Brick Company has a large plant, manufacturing many sorts of pressed brick and tile. This company leases land along the southern part of the outer water front, between Point Richmond and Point Potrero. It has a small wharf in shallow water, from which shipments can be made to bay or river points. Most of the raw material used is mined from the adjacent hills.

Rock Quarries.

There are a number of quarry industries, located chiefly along the outer water front which have an aggregate output of over 400,000 tons of rock per year. Among these concerns are the San Pablo Quarries Company, Healty-Tibbitts Co., John Nicholl Co., Hutchinson Co., Stege Crushed Rock Co. and the Continental Fireproof Co.

Other Industrial Concerns.

Among the other more important manufacturing plants with land owned or leased in Richmond, are the Berkeley Steel Company, California Cap Works, California Chair Company, California Paving Block Company, California Vigorite Powder Company, Central Brick Company, Dupont Powder Company, Enterprise Lumber Company, Great Western Brick Company, Golden Gate Creamery, Jones-

Slattery Planing Mill, Judson Powder Company, Metropolitan Match Company, Presto-lite Company, Pacific Porcelain Ware Company, Pacific Sanitary Manufacturing Company, which has commenced the construction of a $1,000,000 plant; Pioneer Electric Company, Richmond Brick Company, Richmond Furniture Company, Richmond Brewing and Malt Company, Richmond Machine and Iron Works, Richmond Pottery Company, Richmond Lumber Company, Richmond Dredging Company, Stauffer Chemical Works, Shaw-Harrison Gas Engine Company, Tilden & Eakle Lumber Company, Union Sulphur Phosphate Company, U. S. Briquette Company and Western Pipe & Steel Company, the latter being a very large concern.

Public Service Corporations.

The greater part of the city is furnished with its water supply by the Peoples' Water Company, the same corporation serving the adjacent cities of Berkeley and Oakland. The local supply for Richmond is derived chiefly from artesian wells in the San Pablo district a short distance north. Larger corporations, such as the Standard Oil Company, have their own water supply.

The Pacific Telephone & Telegraph Company furnishes Richmond direct communication with the other inter-bay cities. The Postal and Western Union Telegraph Companies, with the American District Messenger Service, are also represented. Electricity for the City of Richmond for power and lighting purposes is distributed by the Western States Gas & Electric Company of California, who purchase their current from the Pacific Gas & Electric Company. This concern supplies the city lighting service, as well as private consumers. The larger manufacturing concerns, such as the Standard Oil Company, Santa Fe and Pullman shops, purchase power direct from the Pacific Gas & Electric Company.

The Oakland Gas, Light and Heat Company has a high pressure gas main leading from Oakland into Richmond, from which gas is distributed for heating and lighting purposes.

Municipal Improvements.

Prior to the annexation of 1912 the city had twenty-one miles of macadam and oiled macadam streets, four miles of asphalt pavement, and forty-three and one-half miles of sewers. The territory recently annexed will add considerable mileage to the above figures.

The parks of the city consist of Janice Park, within the city boundaries, and the private parks without the city boundaries of East Shore Canyon and Grand Canyon.

Richmond school department consists of seven schools, including one union high school. A recent issue of $160,000 is now being expended in rebuilding two of these schools.

Real Estate Conditions.

The present valuations of property within the city are approximately as follows:

Outlying residence section, $15 to $25 per front foot; close in residence property, $25 to $50 per front foot; outlying business property, $60 to $100 per front foot; business property on principal street, $200 to $500 per front foot; factory site acreage, outlying and undeveloped, $500 to $1,500 per acre; factory site property developed and close in, $2,000 to $5,000 per acre.

Insurance rates are as low as 60c on residence property, and the average rate for business property might be conservatively placed at $1.90.

Owing to its rapid growth Richmond is lacking in housing accommodations. There are a great number of small rooming houses, apartment houses, hotels and restaurants, but there is a constant demand for more, especially those that are first-class. At the present writing plans have been prepared for a large modern commercial hotel and cafe.

Richmond's close proximity to the larger cities heretofore caused a great deal of purchasing to be done in adjoining cities. However, with the continued growth of the city the stores are expanding and carrying additional stock, and the tendency is toward patronizing home industry.

Banking Conditions.

The banks of the City of Richmond are four in number. The Mechanics Bank, Bank of Richmond, First National Bank, Richmond Savings Bank. The growth of these banks can be well inferred from the fact that during the period from January 7, 1911, to January 14, 1912, the total deposits slightly more than doubled, and during the same period the total assets increased about 64 per cent.

Newspapers.

There are six newspapers in the City of Richmond as follows: Two dailies, the Morning Independent and the Evening Record-Herald; three weeklies, the Terminal, the Unionist, and the Contra Costan, and one monthly, the Advance.

Miscellaneous Improvements.

The Richmond Industrial Commission and the Richmond Board of Trade are two efficient and aggressive bodies of the city actively engaged in promoting its commercial growth.

Richmond has several theaters, including a new one which has just been completed, with a seating capacity of 1,200, and a well equipped opera house.

Richmond has five modern office buildings and two similar buildings are now in the course of construction.

There are twelve churches in the City of Richmond.

Richmond has one modern fully equipped hospital, together with a sanitorium.

In spite of the fact that Richmond is primarily an industrial community, the death rate of the city is only 5.3 per 1,000.

CHAPTER IX

PROSPECTIVE COMMERCIAL GROWTH.

Labor Conditions at Richmond.

The industrial growth of Richmond has been greatly facilitated by unbroken harmony between labor and employers. The Standard Oil Company, the largest employer in the city, has been noted throughout the country for the absence of serious strikes. Most of the industries located at Richmond have always paid satisfactory wages, and consequently have received the hearty cooperation of the working people and business men of the city.

Housing conditions are good, rents are reasonable and the working population have good opportunities to become independent, through investment in home sites at reasonable prices. An immense area of land has been sub-divided for small home sites, close to the manufacturing centers. A vigorous campaign is kept up at all times to induce immigration to the city. All of these things have given exceptional reliability and permanence to the industries of Richmond, which are favored by the promise of continued industrial peace.

Richmond, An Industrial City.

During recent years the growth of Richmond has been on a sounder and more substantial basis than that of most California cities. In Appendix II is shown the past and present growth

in population and valuation of the city, together with predictions for the future. These indicate, from a standard and conservative method of computation, a probable future population in 1920 of about 37,000 and in 1950 of about 103,000. The present population, including the recent annex, is about 12,000. Similar studies show that the present valuation is about $12,357,799, and that this will probably increase in 1920 to about $33,000,000.

There are many reasons to believe that the future growth of the city as thus indicated by theoretical considerations will be greatly exceeded. Most of the large cities in this country owe their rapid rate of growth chiefly to the development of manufacturing industries. In California this line of development has been generally neglected. Richmond is one of the few cities which has been primarily developed as an industrial community. It has special advantages for such developments, among which are excellent railroad service, deep water, a large level area well adapted for manufacturing or terminal properties, proximity to a large city, which means a cheap and flexible labor market, and cheap fuel, which can be furnished by the pipe lines of the Standard and Associated Oil companies, leading directly from the California Oil fields. This is also a line of development which can profit most from the commercial stimulus following the completion of the Panama Canal, and of the 1915 World's Exposition. The promise of a large population for Richmond is also based upon the many advantages which it possesses in comparison with other cities contiguous to San Francisco. Already there have been sufficient industrial establishments to make it a place of particular importance among California cities. Its promise as a manufacturing center early attracted the most substantial and energetic men, who have advertised it widely, and promoted its growth by inviting manufacturing enterprises and by sub-dividing the surrounding large land holdings into city lots. Because of its particular adaptability for a manufacturing center, it follows that the completion of the proposed harbor improvements will be of more advantage to Richmond than similar work would be to any other of the bay cities. It should insure a growth both in population and in wealth far in excess of the normal and conservative estimates indicated by the theoretical studies of Appendix No. III.

CHAPTER X

ORGANIZATION AND FINANCIAL CONDITIONS OF THE CITY.

Appendix No. VI contains a resume of the City Charter of Richmond and gives full quotations of such clauses concerning the city's organization and power and duties of its officers as effect its ability to proceed with harbor improvements and to properly finance them.

Organization.

From a review of the City Charter it is seen that Richmond is a city of the fifth class, operating under a free holder's charter. The legislative power is in the hands of nine representative councilmen elected at large. One of the councilmen is elected by the council as mayor. The councilmen receive no compensation except when sitting as a Board of Equalization. The executive powers are exercised by the mayor, committees of the council and officials appointed by the council, namely: clerk, auditor, treasurer, assessor and tax collector, police judge, city attorney, city stenographer city engineer and superintendent of streets, city architect, commissioner of health and city physician, sanitary inspector, city chemist, city electrician, chief of fire department, librarian, library trustees and various other officials and attaches of these offices. Most of these officials serve for a term of two years. The Board of Education and school board are elected by the people. The various attaches and officials of these departments are appointed by the respective boards. The City Council appoints from its own members, committees, namely: finance, ordinance, public buildings, licenses, streets, sewers, water, light and fire, police and health. All officials are subject to recall. The city by its charter is limited to a sixty cent tax rate for the conduct of the municipal government. The municipality also has the right to initiate legislation, and exercises referendum on legislation by the City Council. Under the charter the whole organization of the city is well adapted for the construction and operation of any public utilities which might be built or acquired by the city.

The judicial powers of the city are vested in the police court, excepting that judicial determination of anything effecting the

government or acts of governments, would have to be carried, of course, to higher courts, such as the Superior Court of the county or the Appellate Courts of the State or United States.

The City Council and the people have full power to enact such new legislation as is necessary for the conduct of any municipal enterprise which might be started for harbor or other improvements, such as are contemplated in this report. The present charter went into effect July 1, 1909.

FINANCIAL CONDITIONS OF THE CITY.

Property Values.

Appendix II, tables 44 to 47 show studies of the present and future assessed and actual valuation of Richmond, together with a concise statistical history of the financial growth of the city. These show that the assessed valuation in 1911 was $7,888,147.00. The actual valuation in 1912, exclusive of the recent annexation is $10,103,424.00, and inclusive of the annexation is $12,357,799.00. The corresponding predicition for 1915, inclusive of the recent annexation, is $17,800,000.00 and for 1920, $33,000,000.00.

Distribution of Property Values.

It has been stated that Richmond has two distinct centers of population, likewise there are two distinct centers of valuation. One is the older or Point Richmond district on the inner slope of the Potrero Hills, and the other is in the new district lying to the east of the marshy area which passes through the center of the city.

The center of valuation of the entire portion of the city west of Twenty-Third Street and south of Constant Avenue, which limits the northern edge of the improved portion, lies at the intersection of First Street and Macdonald Avenue, a short distance east of the Santa Fe Railroad. This shows that the most valuable real estate in the city lies in the northeasterly quarter of its area. The financial and banking center of the city has always been in the Point Richmond district and centered close to the city hall at Richmond and Washington Avenues. However, a rapid development of the eastern portion of the city has caused a development of a banking center on Macdonald Avenue in the eastern portion of the city. The distribution of assessed valuation is partially shown by the table No. 10 herewith presented, giving the geographical location, area and assessed valuation of different portions of the city and for different classes of property.

Table No. 10—Partial Distribution of Assessed Valuations in Richmond.

Owners	Kind of Property	Acres	Location	Assessed Val.	Val. pr. Acre
A. T. & S. F. Ry. Co.	Station, site yards	459.71	Center of City....	$161,570	$ 351
Standard Oil Co.	Refineries and hill land	413.70	Westerly Water front and hills.	1,762,973	4,261
Schrock Furniture	Fac. site, plain lands	4.23	North City line, Factory st. and Crichett Ave ...	4,500	1,064
E. S. & Surb. Ry. Co.	Car barns, plain land	1.86	Central Richmond, 20th st. and Macdonald ave.	10,150	5,457
Pt. Richmond Canal Land Co	Marsh lands...	305.00	Southwesterly portion of city ...	22,875	75
G. F. Allardt	Tide lands.....	52.69	Westerly portion of city, bet. Pt. Richmond and Pt. Castro	11,065	210
G. W. Haight	Hill lands, unsubdivided ...	24.80	Westerly water front, south of A. T. & S. F. tunnel	5,750	232
Bay Shore Tract	Hill lands, unimproved res. prop	0.58	Front Ave. and Bishop av., westerly water front	1,125	1,940
G. F. Allardt	Tide lands	13.33	Proposed inner harbor tidal basin	832	62
Individual Owners	Improved residence and business prop. Hillside	1.20	Western Richmond Santa Fe ave and Richmond ave...	26,198	21,830
Individual Owners	Imp. business prop., plain lands	1.76	Central Richmond, 8th st. and Macdonald ave.	24,755	14,066
Individual Owners	Unimproved low lands	2.32	Southern Richmond 10th and Potrero ave.	3,800	1,638
Individual Owners	Improved business property	2.71	Central Richmond, 5th st. and Macdonald ave.	45,981	16,967
Individual Owners	Improved Business Property	2.00	Western Richmond Washington ave. and Richmond ave	37,870	16,935

Revenues of the City.

Under the laws of the State of California and the charter of the City of Richmond the revenue for the city government is derived from a general property tax and fees and licenses collected

by the city. The city devotes a portion of its own taxes to the schools, and in addition it receives its proportionate amount of the school funds from state and county taxes. The property within the city is also subject to a general property tax by the County of Contra Costa. The sum of the city and county tax rates gives the total property tax rate within the city. In 1912 a law went into effect in the State of California which provides that railways, banks, telephone and light companies and other public utilities shall pay no city or county taxes, but shall be taxed exclusively by the state.

The greater part of the public works of the city have been financed by special assessments on the particular districts benefited.

Bonded Indebtedness.

The City of Richmond has no bonded indebtedness other than a bond issue of $160,000.00 which was voted for new school buildings. The city charter limits the bonded indebtedness which may be incurred for the development of the water front and harbors to six per cent of the valuation of the city as shown by the last total assessed valuation of the city assessor's rolls. The California State Banking Act contains a provision which provides that savings banks can not loan on municipal bonds of a city which has a total bonded indebtedness of over fifteen per cent of the total valuation shown by the last assessment rolls. The following tables give the total indebtedness which may be incurred for all purposes and the portions which may be incurred for water front improvements, based upon the forecast of Appendix II.

Table No. 11—Forecast of Possible Bonded Indebtedness for Richmond.

(From Appendix No. 11.)

Year.	Actual and Predicted Assessed Value.	Actual and Predicted Population.	15 per cent of Val. or Total Possible Bonded Indebtedness.	6 per cent of Val. or Possible Bonded Indebtedness for water front improvement.
1912	12,357,000	11,500	1,853,000	741,000
1915	17,800,000	17,700	2,670,000	1,067,000
1920	33,200,000	37,400	4,980,000	1,991,000
1930	59,000,000	45,000	8,850,000	3,540,000
1940	85,000,000	62,500	12,740,000	5,100,000
1950	111,000,000	103,000	16,650,000	6,660,000

This table is based on conservative predictions, and while the assessed valuation might be larger, due to unusual conditions which may arise by reason of manufacturing and commercial development, it would not be well to assume a bonded indebtedness beyond that in the figures given herein. The present contemplated improvements can hardly be completed before 1915, consequently bonds could be voted at this time, close to the limit of indebtedness shown for 1915.

In order to study the effect upon the future tax rate of the contemplated harbor improvements, Table No. 12 has been prepared. This is based upon the forecast of future population and future valuation contained in Appendix No. II. It is computed for 40-year bonds, bearing interest at 5 per cent, 1-40 of which is to be retired each year. Part IV of this report contains the estimated cost of the various improvements recommended. The table given below is made out, showing the taxes per $100,000,000 of bonded indebtedness, assuming that it is spent during the year 1913.

Table No. 12—Effect Upon Tax Rate of $1,000,000 Bonded Indebtedness for City of Richmond.

Year	Valuation Assessed	Popu- lation	Bonded Debt	Sinking Fund	Int.	Total Pay.	Per Capita Debt	Tax rate
1913	 13,900,000	13,500	1,000,000	25,000	50,000	75,000	74.07	.54
1914	 15,750,000	15,500	975,000	25,000	48,750	73,750	62.90	.47
1915	 17,800,000	18,000	950,000	25,000	47,500	72,500	52.78	.41
1916	 20,100,000	20,500	925,000	25,000	46,250	71,250	45.12	.35
1917	 22,800,000	24,000	900,000	25,000	45,000	70,000	37.50	.31
1918	 25,900,000	28,000	875,000	25,000	43,750	68,750	31.25	.27
1919	 29,300,000	32,000	850,000	25,000	42,500	67,500	26.56	.23
1920	 33,200,000	37,500	825,000	25,000	41,250	66,250	22.00	.20

The above table No. 12 is computed on the assumption that no revenue is derived from the proposed municipal wharves except sufficient to cover the cost of operation and maintenance. As explained in detail in Part I, the wharf tolls at San Francisco are sufficient to pay all costs of operation and maintenance and provide a sinking fund for all bond issues. Table No. 13, given below, shows that an appreciable revenue is derived from the operation of municipal wharves in other California cities. However, it is not believed to be the best policy to attempt to profit by the operation of municipal wharves because the charges should be made as low as possible, barely sufficient to cover the cost of operation and maintenance, in order to attract all possible shipping so that the city may profit most by commercial development.

Table No. 13—Financial Results of Operation of California Municipay Wharves.

(State Controller's Annual Report, Fiscal Year 1909-1910.)

City	Total Wharf Receipts	Cost of Operation.	Cost of Betterments.	Principal and Interest of bonds.	Total expenditures.	Revenue* Deficit
Berkeley	2,454.08	1,79°.10	....	700.00	8,792.10	1,807.66*
Oakland	13,267.90	4,204.17	....	......	4,204.17	6,338.20†
Oceanside	......	625.24	....	862.50	1,487.74	9,063.20*
Petaluma	......	......	....	322.50	322.50	1,487.74†
Sacramento ...	9,342.10	6,604.28	5,368.62	......	11,972.90	....
Stockton	10,651.11	1,092.00	6,623.56	2,300.00	10,015.56	2,030.80†
Vallejo	1,589.50	635.55	949.80	......	1,585.35	635.55*
Benicia	2,442.41	634.75	14.00	......	648.75	4.15*

For comparative purposes there is given below, Table No. 14, showing the present conditions of various other California cities regarding bonded indebtedness, tax rates, etc.

Table No. 14.

City	Total Assessed Valuation.	Bonded Debt.	Per cent debt of Assessment.	Per capita debt (1910) census.	Total city tax.	Tax rate for Bond purposes.	Bond Interest rates.
Alameda .....$	19,393,490	$ 589,725	3.04	25.22	1.28	.226	4, 4½
Benicia	890,720	103,000	11.55	43.65	1.70	1.20	6
Berkeley	38,540,765	345,790	8.97	8.55	.75	.06	5, 4½
Los Angeles..	374,604,160	23,993,950	6.41	75.14	1.48	.58	3¾, 4, 4½, 5
Oakland	129,220,575	4,907,350	3.80	32.67	1.98	.58	4, 4½, 5
Sacramento ..	44,912,000	1,030,500	2.30	23.05	1.39	.175	4
San Diego ...	46,222,034	2,516,062	5.44	63.57	1.45	.48	4½
San Francisco	545,064,347	18,301,069	3.36	43.90	2.00	.305	3½, 4½, 5
Stockton	22,539,401	249,975	11.07	10.75	1.65	.144	4, 4½

The present and past financial condition of the City of Richmond can be inferred from the following tables, showing receipts, expenditures and tax rates for the last five years.

Table No. 15—Richmond Financial Statement. (1906-1911.)

Year	Assessed Valuation	Receipts	Expenditures	Tax Rate
1906-07	$3,417,270	$33,609	$27,469	35c on $100
1907-08	5,157,520	49,044	47,284	35c on $100
1908-09	6,862,225	64,386	60,191	50c on $100
1909-10	7,610,161	84,943	86,892	65c on $100
1910-11	7,888,147	91,687	97,464	70c on $100

Tax rates for 1909-11 include special school taxes, the charter limit of regular taxation is 60 per cent on the $100.

Table No. 16—Classified Expenditures of the City of Richmond.

	1906-07	1907-08	1908-09	1909-10	1910-11
General Government	$ 6,253	$ 6,828	$11,652	$12,509	$13,408
Protec. life and Property.	7,828	11,760	15,936	21,635	24,169
Health Conservation and Sanitation	720	5,129	5,262	6,379	5,935
Streets and Highways ...	12,398	23,566	26,060	31,568	36,367
Education				30,915	17,543
Recreation			1,280	1,208	43
Totals	$27,469	$47,283	$60,190	$104,216	$97,465

Table No. 17—Public Works—Expenditures—Richmond, 1906-1911.
Work Done Under Supervision of City Engineer—Streets, Highways, Sewers, Buildings.

Year	First Cost Maintenance	Engineering Costs	Plant Cost Maintenance	Totals	Special Assessment Work	Grand Totals.
1906-07	$ 7,786	$ 4,431	$	$12,217	$ 12,677	$ 24,894
1907-08	14,873	7,387	464	22,724	110,288	133,012
1908-09	17,298	9,155	649	27,102	68,387	95,489
1909-10	30,698	10,135	577	41,410	274,335	315,745
1910-11 ...	33,656	8,983	4,280	46,919	200,085	247,004

(Municipal report and City Auditor's report.)

Character of Bonded Indebtedness.

The question of the bonded indebtedness to be incurred by the City of Richmond has been taken up with various bond houses in San Francisco, and it has been found that ready sale for bonds drawing a rate of interest of 5½ per cent will be found in the local markets. The sale of 5 per cent bonds would be reasonably assured. Bonds drawing interest at the rate of 4½ per cent per annum would not find as ready a market, and there might be some question of their ultimate sale. It has also been determined that bonds for municipal improvements in the City of Richmond should not exceed for the purpose of ready sale, more than 10 per cent of the total assessed valuation. For the year 1915, this would practically place the limit of bonded indebtedness at $1,700,000.00. Any municipal bonds which are issued to the City of Richmond should be issued in the principal amount of $1,000.00 for each bond, as this class of bond has a readier sale than bonds issued in lesser amounts, or odd amounts. Of course it may be necessary to issue some bonds for odd amounts, but the number of this class should be limited. The improvement of the outer and inner harbor must come under the 6 per cent limit for harbor improvements, as provided in the Richmond charter.

Other related improvements, such as the propposed tunnel and approach streets, connecting the outer harbor with the inner harbor and the City of Richmond, would be provided for without consideration of the above mentioned 6 per cent limit. Forty-year bonds are recommended, and a longer period would be justified, but is prohibited by law. All construction recommended is permanent and would require little renewal within the forty-year period, hence bonds of shorter period should not be considered, as succeeding generations will benefit most by the proposed improvements and can more easily finance their portion.

Separate bond issues should be provided for the harbor improvements and for the related or secondary work, such as the construction of the tunnel and approach streets. The acquisition of the necessary rights of way for the latter work over regularly subdivided land or tide lands can perhaps be accomplished under the street opening act of 1899, or the street opening act of 1903, by condemnation. Right of way can also be acquired by forming large assessment districts, distributing the cost over the entire city, or at least over the greater portion. The United States has title to the submerged area outside of the pierhead lines. Permission can be secured without cost from the Secretary of War for the construction of the required piers or other improvements. All actual construction work should be paid for from the proceeds of the bond issues. Interest on the bonds must be made to fall due semi-annually and be immediately payable. The City Council is required to levy a tax sufficient for this purpose.

CHAPTER XI

TERMINAL REQUIREMENTS.

Existing Harbor Improvements.

The outer water front has already been improved to a considerable extent through the construction by private enterprise of wharves and piers. Nearly all of this work has been confined to that portion of the outer water front between Point San Pablo and Point Richmond. In this section there are seven wharves now in use. Beginning at Point San Pablo, the extreme northern edge of the Richmond water front, these are as follows: (See Plate 3 and Table No. 18.)

The Richmond Belt Railway Wharf at Point San Pablo.

The Standard Oil Company's wharf at Point Orient.

The California Wine Association pier and wharf at Winehaven.

The Healy-Tibbitts Construction Company quarry wharf at Point Molate.

The San Francisco Quarries Company wharf near Point Castro.

The Standard Oil Company's main pier and wharf at Scofield Avenue.

The Santa Fe Railroad wharf and ferry slip at Point Richmond.

South of Point Richmond and about midway between Point Richmond and Point Potrero, in shallow water, is the small wharf of the Los Angeles Pressed Brick Company. All the others are in relatively deep water, that is, over 20 feet. All of these wharves are owned and operated by the corporations named. The only commercial wharves are those of the Richmond Belt Railway and the Santa Fe Railway, which receive or transmit on their wharves merchandise consigned over their lines. The others are for the exclusive use of the owners named. All of these wharves or piers are of more or less temporary construction, being composed entirely of timber structures, although the piles are in some cases well protected against the attacks of marine borers.

The following Table No. 18 gives segregated information regarding the dimensions, design and character of these piers and wharves.

TABLE Nº 18

RICHMOND HARBOR REPORT PAGE 105.

GENERAL DATA
ON
WHARVES AT RICHMOND

OWNER	LOCATION AND NAME	KIND OF PILING	HEIGHT ABOVE L.W. WATER AND DEPTH AT LOW W.	PLAN
RICHMOND BELT R.R.	POINT SAN PABLO WHARF	UNTREATED OR PARTLY PROTECTED BY CONCRETE	D = 30'	
STANDARD OIL CO.	POINT ORIENT WHARF	UNTREATED OREGON PINE	D = 30'	Single Spur Track Width 20, Length 780
STANDARD OIL CO	SCOFIELD AVE. WHARF	UNTREATED OR PARTLY PROTECTED BY CONCRETE	H = 12 D = 25	Width 18, Single Spur Track Length 3340
CAL. WINE ASSOCIATION	WINEHAVEN	UNTREATED OREGON PINE	D = 24	Width 29 Single Spur Track Length 1900 Single Spur Track
HEALY-TIBBITTS CONSTRUCTION CO.	MOLATE POINT QUARRY WHARF		D = 18'	Length 960 Width 28 Double Spur Track
SAN FRANCISCO QUARRIES CO.	PT. CASTRO	OREGON PINE	H = 13 D = 24	Length 366 Width 28 Double Spur Track
SANTA FE RY CO.	POINT RICHMOND	CREOSOTED OREGON PINE	H = 12 D = 24	
LOS ANGELES PRESSED BRICK CO.	BRICK WORKS EAST OF POINT RICHMOND	UNTREATED OREGON PINE	D = 5	Length 460 Width 15'

Flood Tide Velocity Measured at Standard Oil Pier at 2 P.M. July 6 1912 = 1.7 ft. per Sec
1.13 Mi. per Hr.

Howland & Tibbetts
Civil Engineers   San Francisco

In the inner harbor at Ellis Landing there is a small timber wharf, but this can be approached only through a long reach of very shallow water, part of which at low tide is a winding slough.

Water Front Ownerships.

The submerged land along the water front of Richmond has all passed into private and corporate ownership. Most of it is in relatively shallow water and has been subdivided into twenty-acre lots and sold by the State Tide Land Commission. The frontage of these ownerships in general is still undeveloped and unoccupied. Government bulkhead and pierhead lines are fixed without reference to the bounderies of the tide lands.

Acquirement of Water Front.

If Richmond is to develop a municipal harbor, the first step is to acquire title, to a portion at least, of the submerged tide lands along the water front. This ought not to be very difficult or expensive, because the property sought is, in general, unoccupied and unimproved, and the city has the unquestioned right to condemn, if necessary, the land desired for immediate use. If, however, it could be proved that any of the property sought was operative or in actual use, then the valuation allowed in a condemnation suit would probably be high. It could be obtained with certainty, however, as the use of property by a municipality is considered a higher use than by a private corporation. In order that the way might be clear for comprehensive development on both outer and inner harbor, it would be desirable to acquire title to all of the submerged tide land along the water front from the Standard Oil Company's main pier at Seofield Avenue, southward to Brooks Island and Point Isabel, excepting land partially occupied by the Santa Fe terminal. This would amount to about 1,490 acres in three sections as follows:

Between Standard Oil Company's wharf and Santa Fe mole at Point Richmond, 360 acres.

Between Santa Fe mole at Point Richmond, Point Potrero and Brooks Island, 301 acres.

Inner harbor, between Point Potrero, Brooks Island, Point Isabel, Stege and Ellis Landing, 829 acres.

Local Lines of Communication.

Reference to Plate No. 3 (City of Richmond), shows that the main portion of the city east of the central marshy area, is laid

out in rectangular blocks. One of the most important thoroughfares is Macdonald Avenue, which is the axis of the business district, and carries the East Shore and Suburban street car line between the Southern Pacific and Santa Fe Railway depots, and passes through both the newer or eastern section of the city and the older, or Point Richmond section. The Point Richmond section, lying principally on the eastern slopes of the Potrero hills, has an irregular and winding street system, adapted to the topography. The principal line of communication is Standard Avenue, running along the base of the hills and carrying the East Shore and Suburban street car line from the Standard Oil refineries into the business section. The business district embraces the territory from Nicholl Avenue to Standard Avenue, extending along Washington Avenue, from the Point Richmond station of the Santa Fe, at the southern end of Standard Avenue up the slope of the hill and past the city hall. The old and new districts are at present connected by one improved street and a street car line, running along the southwesterly edge of the Santa Fe yards. There is an agreement between the city, the Santa Fe Railroad Company and the East Shore and Suburban Railway whereby the street car tracks and improved highway will be placed on Ashland Avenue and the present street given over to the Santa Fe Railroad. Ashland Avenue will then be the most important and most direct line of communication between the old and new settled portions of the city. The extension of the city southwestward promises to make an important street of Cutting Boulevard, which is parallel to and one-half mile south of Macdonald Avenue, and leads directly east from the Point Richmond district. It should ultimately get its share of the Oakland traffic bound for Point Richmond.

It will be seen that most of the important lines of communication intersect within an area having a radius of two blocks in the Point Richmond section. The city hall is within that distance of the intersection of Ashland Avenue, Railroad Avenue, Cutting Boulevard and the Santa Fe Railroad. Traffic from the main eastern portion of the city will all focus at that locality, which should be the beginning of whatever new line of communication is developed toward an outer harbor project.

Harbor Requirements.

It has been shown that Richmond is developing primarily as a manufacturing or industrial community; that it is the focal point

of a rich and productive tributary territory; that it is already provided with good rail transportation, and that it is favorably located along the shore of San Francisco Bay, but that it has no public water front facilities.

The project recommended by the Government engineers for the inner harbor will provide a tidal canal and a dredged basin 1,800 feet in width by 3,000 feet long (to be later extended to about 10,200 feet long) just inside of Point Potrero and Brooks Island. An entrance channel, protected by a training wall, will be dredged inward past Point Richmond and Point Potrero, and the basin will have an arm 600 feet in width reaching northward from Point Potrero to Ellis Landing.

In accordance with a well established policy, however, the Government will do no work shoreward from the pierhead lines, except the depositing of material dredged from the channel. It will probably be required that suitable bulkheads be constructed to retain the dredged material before it will be deposited upon lands not owned by the Government. In general, then, the Government project will provide and maintain a channel and tidal basin properly protected and forming in effect a deep extension of the bay into the shore. None of this work, however, will provide facilities, such as wharves or docks for unloading ships.

Assuming that the Government project is completed as recommended, the city should undertake simultaneously the construction of wharves or docks at either end of the Government project.

Harbor Developments.

The city should at once acquire title to submerged areas adjacent to the Government channel in order that advantage may be taken of the Government dredging work to reclaim the submerged areas by filling them with material dredged from the channel. In order to accomplish this it will be necessary to construct substantial bulkheading along the channel to retain the desired fill. This will probably be required along the bulkhead line between Point Richmond and Point Potrero and along either side of the arm of the Government channel extending towards Ellis Landing and probably to some extent along the northern side of the main channel east of Point Potrero.

A pier or wharf should be constructed in the nieighborhood of Point Richmond at the outer end of the Government channel for vessels of maximum draft. It should provide for ships with a draft of at least 30 feet and should be so designed that this could ulti-

mately be extended. Wharves in this vicinity are also very desirable in order that river and bay steamers going from San Francisco to San Pablo Bay or to Sacramento or San Joaquin river points may stop to discharge or receive freight and passengers. A pier along the Richmond water front anywhere in the vicinity of Point Richmond could be made a point of call for any river or bay craft without increasing the length of their course if they were routed east of Southampton Shoal. This is a traffic which is very important and increasing, and from which Richmond does not profit at present.

As this district is separated by the steep ridge of the Potrero hills from the improved portion of the city, a low, level tunnel should be provided to give access to the outer harbor. This low, level tunnel should preferably start near the point where it has been shown that traffic naturally focuses, that is, near the present city hall. The tunnel approaches should be located so as to eliminate as far as possible grade crossings of the Santa Fe Railroad, and so as to benefit the development of the outer slope of the Potrero hills.

The second development should take place at the inner end of the arm of the Government channel extending northward toward Ellis Landing. This should consist of a wharf or wharves having twenty feet of water and designed so as to be ultimately extended to thirty feet. Perfect shelter would be afforded for small or medium size craft which would thus be enabled to discharge their cargo at a point far in toward the industrial center of the city.

Special attention should be paid to the advantageous location of a belt line railroad connecting up the two harbor projects with each other and with other railroads and the industrial sections of the city in such a way as to best serve all probable improvements.
Mechanical Freight Handling Equipment.

In most European harbors dock cranes are provided for use in loading or unloading vessels. In American ports, and particularly on the Pacific Coast, there is little mechanical freight handling apparatus, but the cargo is handled exclusively by the ships' tackle and stevedores. This is believed to be one of the reasons why, in spite of favorable harbor conditions, the total port charges, including harbor and wharfage dues, pilotage, stevedoring and all others at San Francisco are somewhat higher than the average at the principal foreign ports. An analysis of the reasons for this as given on page 15 of the Wagoner-Heuer report on San Francisco harbor, shows that the excessive cost of port charges is due en-

tirely to the high cost of labor. Stevedore charges are almost twice as much as the average of six prominent European ports. This indicates that any mechanical method of handling freight by which stevedoring charges could be reduced would be of special advantage at any San Francisco Bay port. Steamers doing business in American ports, and particularly on the Pacific Coast, are usually equipped with means for handling cargo by ships' tackle. With the opening of the Panama Canal, however, Pacific Coast ports will be visited by foreign ships accustomed to doing business at ports where cranes are provided, and hence not as favorably equipped for handling their own cargo.

Both of the conditions described above make it evident that special attention should be paid at Richmond to providing municipal wharves with mechanical freight handling apparatus in order that shipping might be attracted by the minimum port charges.

Municipal Ownership.

The advantages of municipal ownership and operation have been so abundantly demonstrated that they are generally conceded. In previous chapters on Port Requirements it is shown that the cost of such developments should be a charge on the community as a whole and that the cost of operation should be reduced to a minimum. It has been the universal experience of cities with natural advantages as terminal points that they have been compelled to expend large sums in acquiring property for public terminals after the most valuable portion of their water front had been improved by private interests. San Francisco is one of the few cities in this country in which the water front has always been public property. Richmond is now in a position to acquire the land necessary for such improvements and to immediately start improvements along the two lines indicated. For comparative purposes, and showing Richmond's opportunities, there is given the following table, showing in a concise form the division of ownership of water front facilities at various important ports of this country.

Table No. 13—Ownership of Docks and Wharves—American Ports.

City		Ownership
New York	Public	Private and Railroad
Baltimore	Public	Private and Railroad
Norfolk	Public	Private and Railroad
New Orleans	Public	Private and Railroad
Boston		Private and Railroad
Philadelphia		Private and Railroad
Newport News		Private and Railroad
Savanah		Private and Railroad
Charleston		Private and Railroad
Galveston		Private and Railroad
San Francisco	Public	Private and Railroad
Los Angeles	Public	Private and Railroad

Comprehensive Plans Required.

It has been shown as a general principle that the most rapid port development occurs only where improvements have been carried somewhat in advance of actual needs.

There appears to be immediate demand for harbor development, both at the outer edge of the water front at Point Richmond and at the inner end of the proposed Government channel. The outer project possesses the advantages of easy provision of deep water and direct access to the Golden Gate, and possesses entirely independent advantages as a port of call for river and bay traffic. The inner project possesses the advantages of being perfectly protected and extending far inward toward the interior of the city. Twenty feet in depth, as shown in Appendix No. III, will provide for much the larger portion of the traffic which might be expected.

Before any important development is undertaken comprehensive plans should be outlined for the improvement of the entire water front in order that any work done at the present time might become an integral part of the final scheme.

PART IV

Proposed Harbor Improvements

CHAPTER XII

PLANS FOR ULTIMATE HARBOR DEVELOPMENT.

The plans for the ultimate development of Richmond harbor are shown in general on Plate 5, and are based upon the assumption that the Government project, as recommended by Colonel Rees, and as shown on Plate 5, will be completed. This project, as partially described in Chapter XI, Page 79, will provide a large enclosed basin in the area between Point Potrero, Brooks Island, Point Isabel and Ellis Landing. For convenience of description the Richmond Harbor Project will be divided into three main divisions as follows: **Division No. 1, "The Point Richmond Section,"** extending from Point Richmond to the western side of Point Potrero; **Division No. 2, "The Ellis Channel Section,"** occupying the frontage from Division No. 1 around Point Potrero and along both sides of the proposed Government channel to be dredged northward to Ellis Landing; **Division No. 3, "The Inner Basin Section,"** comprising the main area of the proposed Government basin and extending eastward from Division No. 2 and Brooks Island to a point near the northern shore of Point Isabel.

In the Government project Division No. 1 consists of a channel 600 feet wide and about 10,000 feet long from deep water in the bay to the eastern side of Point Potrero.

Division No. 2 consists of a channel 600 feet wide and about 4,000 feet long from the north line of Division No. 3 to Ellis Landing.

Division No. 3 consists of a wide channel or basin 1,800 feet wide and 10,200 feet long between channel lines. It is proposed at present to dredge Division No. 1, and approximately the western third of Division No. 3, to a depth of 24 feet at low tide and to dredge Division No. 2 at present to a depth of 20 feet, to be ultimately deepened to 24 feet, as conditions warrant. The material excavated to form the channels is to be used in filling and reclaiming the adjacent tide lands. The channels will be protected by a training wall extending westward from Brooks Island on the south side of Division No. 1 to a point immediately south of the Santa Fe wharves at Point Richmond. Division No. 3 will also be protected by a dike extending from Brooks Island to Point

Isabel and forming with the training wall a tidal basin concentrating tidal currents in the dredged channel in order to prevent silting as far as possible.

The works herein recommended have been planned with regard to the ultimate development of the entire water frontage provided by the Government harbor lines, as shown on Plate 5. Full development is provided for the side of the channel and basin lying toward the city, and for both sides of the Ellis Channel. All improvements are based upon the assumption of ultimate provision of 30 feet of water at low tide. The total length of pierhead line provided in the Government project along the northern or city side of Divisions 1 and 3 and along both sides of Division No. 2 is approximately 25,740 feet, or nearly five miles. Plans are provided for the ultimate development of this entire frontage with a comprehensive system of wharves and piers.

The frontage along the outer channel between Point Richmond and Point Potrero (Division No. 1) should be developed for large ships, as it is easier to provide deep water in this vicinity and large ships might have difficulty in maneuvering in the narrow northern arm of Division No. 2. In this outer area a bulkhead wharf is provided at the extreme outer end to accommodate deep water ships and to provide a convenient port of call for river traffic. The remainder of the space is utilized by 11 large piers extending normal to the axis of the channel and harbor lines. These piers are to be 160 feet in width, 750 in length, and separated by slips 300 feet wide. They will provide berth room for the largest ships which may reasonably be expected to visit this locality. The total length of berth room alongside the sides of these 11 piers is 16,500 linear feet.

In order to provide the length shown, it will be necessary to construct a permanent sea wall 150 feet in the rear of the Government line.

A continuous bulkhead wharf is recommended around Point Potrero and along either side of the northern extension of Division No. 2. The total length of wharf approximately equals the total length of berth room provided in this way, and is about 10,150 feet.

Along the northern edge of Division No. 3 are shown 21 piers normal to the bulkhead and pierhead lines. These are 600 feet in length, occupying the entire space between the harbor lines. The piers are 160 feet wide and are separated by slips 300 feet in width. The total length of berth room provided is 25,200 linear

feet for all of the 21 piers exclusive of the outer ends and the space in the sea wall at the inner ends of the slips.

This gives a total length of berth room in the three divisions as follows:

Division No. 1. (Point Richmond Section.)

11 Piers, at 1,500 feet	16,500 feet
Bulkhead Wharf at outer end	800 feet

Total for Division No. 1 .... 17,300 feet

Division No. 2. (Ellis Channel, including frontage of Pt. Potrero.)

Bulkhead Wharfing .... 9,450 feet

Division No. 3. (Inside Basin, northern side only.)

21 Piers, at 1,200 feet .... 25,200 feet

Grand Total, 51,650 feet or 9.78 miles.

Using Wagoner-Heuer's estimate of 630,000 tons freight per annum per mile of berth room, this is sufficient to provide for a total annual commerce of 6,160,000 tons, or about 90 per cent of the freight tonnage of San Francisco in 1907, as given on Page 28 of Part I, as 6,802,793. If further room is desired it can be provided by a similar set of piers along the eastern and southern edges of the inner basin. There is also ample room for future development along the water front north of Point Richmond in front of the Potrero hills.

Acquirement of Tide Lands.

In order that the city may profit most by the harbor developments and in order that they may at all times be under municipal control, it is proposed that the city acquire eventually all the land fronting on the harbor. It is not necessary to acquire a strip more than 250 feet wide back of the bulkhead line for roadway and wharves to effect the desired control. In order that the city may profit most, however, and be in a position to best regulate and develop the entire water front area, it is desirable to acquire a larger area of submerged land back of the bulkhead line, and perhaps include all of the submerged land lying between the Government harbor lines and the shore line. These lands, when acquired and reclaimed, will have an ultimate value of $1,000 to $1,500 per acre, and should prove a very profitable investment for the city.

Reclamation of Tide Lands.

The lands proposed to be acquired are nearly all submerged at high water. They can be readily reclaimed by filling them above high water with material dredged from the harbor channel and basin. If these lands were municipally owned and provisions were made by temporary or other bulkhead to retain the dredged material, it is probable that the fill could be obtained without cost, as the Government would be willing to deposit material upon property owned by the city and to be reclaimed for terminal purposes. The fill should be made to elevation plus 10, or 3 feet above extreme high tide. For the area inside of the proposed sea wall in Division No. 1 between Point Richmond and Point Potrero, this will require about 3,967,000 cubic yards. For the area west of Division No. 2 there will be required about 360,000 cubic yards, and for the area between the shore and the east side of Division No. 2 and the north side of Division No. 3 there will be required about 7,050,000 cubic yards. The total for these three areas being about 11,500,000 cubic yards. The total volume to be dredged in the construction of the proposed Government channels is about 18,000,000 cubic yards. From 3,000,000 to 5,000,000 cubic yards of this will probably be required for the construction of the required dike and training wall. This will leave about 2,500,000 cubic yards, or about 14 per cent in excess of that required for the fill. This excess yardage can probably be sold for the reclamation of private holdings, and any further excess can be wasted outside of the harbor lines.

To retain the proposed fill will require the construction of temporary wooden bulkheads fronting the areas to be filled, except where permanent structures are first constructed. The total lengths of these frontages are as follows:

Along Division No. 1, between Point Richmond and
   Point Potrero .... 5,600 lineal feet.
Along west edge of Division No. 2 .... 4,150 lineal feet.
Along east side of Division No. 2 .... 2,400 lineal feet.
Along north edge of Division No. 3 ....9,500 lineal feet.
                                            ―――――
   Total 21,650

Subdivision of Municipal Land.

It is proposed to subdivide the land into large lots for factory and industrial uses. The streets are laid out in a rectangular system to give the most advantageous building sites, and are located

as extensions of the present street systems of the city. The street plan for the areas fronting on the inner harbor have to conform to the existing street system of the city. The street plan in the area along the north bulkhead line of the outer harbor channel consists of one broad street along the water front, with large blocks and cross streets back of it. Further subdivision of either of these areas can be readily made as developments justify. The two ends of this water front street are connected to the present street system through a cut at each end, one through Point Richmond and the other through Point Potrero. The Point Richmond cut is a portion of the tunnel and roadway described in the supplementary report. The Point Potrero cut, it is expected, will not be made until there is a demand for direct connection between the inner and outer harbors and the extension of a Belt Railroad between the two.

Belt Line Railroad.

The general plan of the Belt Railroad is to provide the whole harbor scheme with direct connection between its various units and with all the railroad systems and terminals in the city. The plan delineated shows the Belt Railroad connecting with the Southern Pacific at a point south of Stege; thence running along the northern bulkhead line to the tidal basin and around the Ellis Channel to the Point Potrero cut, thence along the north bulkhead line of the outer harbor channel through the Point Richmond cut; thence along the proposed tunnel and roadway and through the tunnel to a connection with the Santa Fe yards in Richmond. The Belt Railroad should also be connected with the Santa Fe at Ferry Point or some place between Ferry Point and the present freight yards. Spur tracks should be provided for each of the piers and along the bulkhead wharves and adjacent streets. Switch and storage yards should be provided for each of the three main divisions of the harbor. The exact location of these yards will depend entirely upon the development of the adjacent property and can not be determined in advance. The Belt Railroad should be constructed to carry the standard rolling stock of the Southern Pacific and Santa Fe systems so that there may be no delay and inconvenience in handling consignments from or to either railroad. The inclusion of the tunnel as a part of the Belt Railroad system, will require the use of electric motors. This special equipment should be required by the city when the development of the city's commerce demands it. In the design of the tracks and track sup-

ports on the inner and outer wharves the assumption should be made that the heaviest types of locomotives in common use, will be used. Typical weights of heavy locomotives, commonly known as Coopers E-50 Loading, have four loads of 50,000 pounds per axle spaced five feet on centers. The design of the wharves for this loading will provide also for the heaviest type of electric motors now in use. The sharpest curves on the main line of the ultimately developed railroad should be 24 degrees. The turn outs from the main line on the wharf plans should be 24 degrees, with a radius of 240 feet. The radii of turn out curves may be made as short as 150 feet and still permit of ordinary freight cars being run over them without the corners bumping. It is not desirable to use curves of such short radius where it can be avoided, but at the same time it does not pay to make a saving in the maintenance of track and car wheels running over the easier curves, at the cost of building a greater wharf area or using up valuable space on land to obtain the easier curves. The maximum grade on the Belt Railroad located through the tunnel and the outer harbor roadway will be 2.12 per cent. This grade will not interfere materially with the economical operation of the Belt Railroad as a freight line, because the average speed in hauling freight trains and in switching on the Belt Railroad will hardly exceed ten miles per hour and can easily be obtained on a 2 per cent grade without unnecessary wear and tear on the rolling equipment or excessive consumption of power.

CHAPTER XIII

PRESENT DEVELOPMENTS RECOMMENDED.

For the present proposed bond issue it is recommended that wharf construction be commenced in Division No. 2 at the extreme inner end of Ellis Channel, the point nearest the center of the city and in Division No. 1 at the extreme outer end of the Government project at Point Richmond. About 1,000 feet of berth room should be provided at each location. The inner wharves which will naturally be for smaller ships, should have two 400-foot sheds and be provided with railroad tracks and mechanical freight handling devices. There should also be provided landing stages for small boats or tugs. The outer wharf should be of more substantial construction, as it is in a somewhat exposed location, and should provide for the largest ships which can be expected to visit that lo-

cality. It should also be designed independently for the convenience of river boats in order to induce them to make it a regular port of call. The exact construction of both inner harbor and outer harbor wharves will be described in detail in Chapters III and IV.

Acquirement of Land.

The city should acquire at the present time sufficient submerged land to receive the material which will be dredged by the immediate construction of the Government harbor project.

In order to make it possible to construct piers and to dredge slips as desired it will be necessary for the city to acquire the land from the shore line out to the pierhead line in all cases. Three separate parcels of land will be required for this purpose.

Parcel No. 1 is in Division No. 1 and includes about 247 acres, of which about 131 acres are in the rear of the proposed sea wall and should be reclaimed with material dredged from the Government channel.

Parcel No. 2 is a strip of land around Point Potrero and the western and northern edges of Division No. 2, 250 feet in width. The pierhead and bulkhead lines coincide along this section, and hence all of the land could be reclaimed. It contains about 36 acres.

Parcel No. 3 includes the land lying between the east edge of Division No. 2 and the western third of Division No. 3, which it is proposed to dredge immediately, and the shore line extending easterly from Ellis Landing. This parcel is arbitrarily bounded on the east by a north and south line forming an extension of the eastern end of that portion of Division No. 3 which it is proposed to construct immediately. This is an area about 2,800 feet in width, north and south, and 3,000 feet in length, east and west. It contains about 246 acres, of which 196 acres are back of the bulkhead lines and can be reclaimed with dredged material.

Prior to beginning the Government project the city should also acquire and deed to the Government rights of way over the tide land lots for the proposed training wall and dike, as shown on Plate 5. A strip of land somewhat wider than that used by the actual structures will probably be required in order that the Government may have some additional area which could be rendered valuable by filling, thus partially reimbursing the Government for the cost of the dredging work. The bulkhead line will probably be moved southward to the north line of the fractional tier of tide

land lots extending westward from Point Isabel, so that the area to be acquired will consist of this tier of fractional lots, and a portion of the adjoining tier on the south, including about 219 acres.

The area for the training wall west of Brooks Island will include the tide land lots, in which it is located, as far northward as the pier head line, comprising about 54 acres.

The total areas of land to be acquired are:

For reclamation by the city .... 363 acres
For the construction of future piers and slips........... 166 acres
For deeding to the Government .... 273 acres

Total .... 802 acres

It would be desirable at this time to acquire as much more submerged land in the vicinity of the Government harbor lines as the available funds will permit.

It is quite necessary that the areas given above should be immediately obtained to provide room for disposing of the dredged material, as the Government would probably be less willing to dispose of this on private lands. Experience has shown it might be difficult to get private owners to agree to receive it, even though it would greatly increase the value of their lands. The economic gain to the city by having its lands thus reclaimed with no expense but that of the bulkheading would be of very great importance.

The ownerships of all these lands have been obtained from the county records at Martinez, as far as the records show any ownership. The ownership of some of the lands is not known by the county officials and other lands show conflicting ownerships. These ownerships are shown on Plate No. 3. The acquisition of the lands by the city under these conditions will require careful legal proceedings, accompanied by adjudication of the boundaries and subsequent surveying in order to properly determine the areas for which the several owners are to be compensated in condemnation proceedings or direct sale.

Reclamation of the Tide Lands—Bulkheading.

In order to retain the excavated material upon the tide lands acquired, temporary bulkheads will have to be constructed along the U. S. Government bulkhead line or proposed sea wall line and

running back to higher ground. The surface of the finished fill will be at an elevation of ten feet and the average depth of fill will vary from five to sixteen feet. The total fill on the outer area will have an average depth of about 16 feet. The areas on the inner harbor will vary from seven feet in depth at the high tide line to about 10 feet at the bulkhead line. The temporary bulkhead as detailed on Plate 7 will consist of a single row of vertical piles spaced on 10-foot centers in Division No. 1 and 16-foot centers in Divisions Nos. 2 and 3, with a brace pile supporting each vertical pile and a close wall of sheet piling on the land side to retain the mud fill. It will be located on the bulkhead or sea wall line and its top will stand at elevation 8. It will be constructed entirely of creosoted timber, which should give it a life of about twenty years. The fill will slope landward from the bulkhead, from elevation "0" to elevation 10, on a fairly steep slope which will be built up in the process of filling with a hydraulic dredge by means of temporary retaining supports.

The volume required to make the outer fill is about 3,967,000 cubic yards. This will be dredged directly from the entrance channel, and then pumped over the bulkhead with a short length of discharge pipe. The volume required for the inner fill is about 3,210,000 cubic yards and the material for the west side of the Ellis Channel fill about 360,000 cubic yards. The material for this must be dredged from the inner end of the entrance channel and from the portion of the tidal basin that will be excavated in the first Government project. It is probable that the first dredging done on the Government project will consist of the excavation of the channel complete from Ferry Point around Point Potrero to Ellis Landing. The lands which are proposed to be acquired require a total volume for filling of about 7,537,000 cubic yards. The available material from the Government channel excavated as assumed, and deducting the material to be used in training wall and dike, will be about 6,500,000 cubic yards. The completion of Division No. 3 by the Government will follow and the material can be disposed of on the unfilled area to be acquired by the city, and on the land of any private owners who may desire it.

Subdivision of Lands and Street Plan.

The outline of the complete street plan for the municipal land is given in Chapter XII, Page 89. The subdivision of the outside area between Point Potrero and Point Richmond area is very simple, as only one treatment of it is possible. It is evident that

it must be laid out with a broad thoroughfare next to and parallel to the bulkhead line with the back area subdivided into large factory lots. The width of the main thoroughfare will be 150 feet. This thoroughfare must be the main highway for team traffic along the water front and also must eventually carry the belt line railroad with the turnouts to the wharves and piers. The cross streets are to be 80 feet wide and enclosed blocks 850 feet long, parallel to the main thoroughfare and of varying width back to the shore line. The street layout along the west side of the Ellis Channel is controlled by the location of the Belt Railroad, and the fact that only a small strip is to be acquired by the city. It will probably be best to acquire only sufficient width for the main roadway along the water front and leave the subdivision of the lands back of it to private enterprises. This thoroughfare should also be 150 feet in width. The street system for the larger inside area is made to conform to the present street system of Richmond, Pullman and Stege. The main thoroughfare along the water front is to be 150 feet wide and the ultimate development of the plan will show a rectangular system of streets 80 feet wide. Enclosed blocks are to be 800 feet by 1,250 feet and 23 acres in area. More detailed subdivisions of these areas can be made as improvements justify. The initial development requires that Ninth street should be extended directly south to the first unit of inner harbor wharves, and a connection made with Tenth Street at the San Pablo boundary. The extension of Ninth Street will be 70 feet wide, including 12-foot sidewalks on each side. The paving will be of broken stone macadam, with a tar macadam surface, laid on a foundation of broken stone upon the fill which will be necessary to bring the street up to grade. It is not advisable to construct a very permanent paving on this extension until the fill upon which it is built has settled and become stable and firm. The length of Ninth street extension will be 2,850 feet. It will include that portion of the main water front thoroughfare required to serve the first unit of the inner harbor wharves. No other street improvement is contemplated in the present project, except the tunnel and roadway shown in detail in the supplementary report.

Belt Railroad.

The ultimate plan for the Belt Railroad was sketched in Chapter XII, Page 89.

Franchises properly guarded and for a limited term of years could be granted to existing railroads in this vicinity to permit of the operation of freight cars on the proposed wharves.

Supplementary Report.

In order to provide facilities for reaching the outer wharf a low level tunnel and roadway should be immediately constructed from the probable focal point of the Richmond traffic along the most favorable alignment to the outer wharf. This is not properly a part of the harbor improvement, and hence will be treated in detail in the accompanying supplementary report.

Wharf Construction Recommended at Present Time.

The total wharf construction suggested above and described in detail in the following two chapters is more costly than the present financial ability of the city will justify, and probably more comprehensive than its immediate commercial requirements will warrant. If, as is confidently expected, the growth of the city's commerce will within a very short time demand the completion of the wharves shown in detail, then it is probable that the corresponding increase in valuation will permit of the supplementary bond issues necessary.

Both outer and inner wharves have been designed in a system of units in order that they may be partially completed at the present time and so that all construction will be an integral part of future requirements.

For the outer wharf as shown in detail in the following chapter it is recommended that the end pavillion with the end two sets of three bays each, be omitted at present. This will cut off approximately 225 feet of wharf shed and 255 feet of sub-structure. The temporary end of the wharf should be finished with 12x12 feet solid timber sheet piling, and the temporary end of the shed with corrugated iron, supported on timber framing.

The inner wharf system, as described in detail in Chapter XV, is composed of two distinct units, only one of which should be constructed at the present time, with only half of the interior small boat basin. This will include exactly what is shown on Plate 8.

The installation of all mechanical freight handling apparatus will be delayed until such time as the demand for it insures its immediate use.

CHAPTER XIV

OUTER WHARF IN DIVISION NO. 1 (POINT RICHMOND SECTION.)

Location.

The location of the proposed outer wharf in division No. 1 (Point Richmond section) is close to the Santa Fe wharves on the southern side of Point Richmond near the outer end (see Plates 3, 5 and 11). The wharf shed is to have its center opposite and facing the proposed new roadway, whose outer end will be through a deep cut at Point Richmond, as described in the accompanying supplementary report. The wharf will parallel the U. S. Government bulkhead line with the outer line of piles at the extreme edge of the bulkhead line. The longitudinal axis of the wharf will then be parallel to the bulkhead, pierhead and channel lines and normal to the outer end of the new roadway. It will be near the outer end of the Government dike on the south side of the new channel and protected by the dike from the south storms. The area between the bulkhead and pierhead lines and out to the Government channel line will be dredged in front of the wharf and at either end of the wharf along lines, making an angle of 30 degrees with the bulkhead line, as shown in detail on Plate 5.

Type of Wharf.

The proposed wharf will be at the extreme outer end of the proposed harbor developments, and will be the only bulkhead wharf in division No. 1 (the outer harbor area) between Point Richmond and Point Potrero. It is desired to provide immediate accommodations for the largest ships, as well as for smaller, light draft river boats.

The determining factors in the selection of a type of wharf or pier are the width and depth of the channel, the exposure, the character of the foundation material, the required freight handling capacity, and the space available in working out the ultimate plan. The bulkhead type of wharf, with its axis parallel to the shore line, as distinguished from piers with axis normal to the shore line, is best suited to the immediate and local needs. The

Government channel at this point is only 600 feet wide, and as the proposed wharf is to be built at the extreme outer end of the channel and close to the end of Point Richmond, there will probably be tidal currents which will make it difficult to maneuver large ships in the limited area. By using the bulkhead type of wharf it is possible to practically double the width of channel. The outer end of the wharf, which is designed to be used for river boats, will be set far enough back so that it will be partially sheltered by the Santa Fe wharves at Point Richmond. For the immediate future a single bulkhead wharf can be best designed, with suitable dimensions for the expected volume of traffic. In a bulkhead wharf the problem of providing sufficient storage room is more easily solved than with the pier type, because the entire area back of the bulkhead line for the full length of the wharf is available for storage and may be considered directly in touch with the water front. In the pier type only half the width of the pier can be considered available for temporary storage for a vessel unloading alongside. As the remainder of the space between Point Richmond and Point Potrero, which is ultimately to be used for deep water ships, is somewhat better protected and will be filled with piers, there is sufficient room for one large bulkhead wharf without an unreasonable sacrifice of berthing room.

The foundation material at the location chosen is shown by borings to consist of a deep layer of mud to a depth of 40 to 50 feet, or down to elevation minus 50 to minus 60. Under this is hard clay, extending to unknown depth. A single bulkhead wharf requires a greater length of sea wall to be constructed than a single pier, but because of the hard underlying material, it is possible to utilize the bulkhead wharf for fixing the top of heavy sheeting, which will be designed to act as a sea wall, retaining the mud so that a full depth of 30 feet can be secured at the outer edge of the bulkhead pier.

Architectural Treatment. (See Plate 6.)

The building of the wharf shed is designed in Renaissance style of architecture, with simple but massive features. The structure is 740 feet long, divided into thirty-seven 20-foot bays. The center and ends have been treated as pavilions projecting 12 feet in front of the face of the wall, and rising five feet above the main cornice. The center feature occupies five bays, the three center bays being filled in with rolling lift doors, 16 feet wide and 24 feet high, surmounted by transom windows. The other two bays

are treated with channeled pilasters 3 feet 6 inches wide. Inside these pilasters are placed three-quarter columns with moulded base and doric cap. Between these columns are placed two windows. The two ends of the building are treated in a similar manner, but occupy only three bays and have only one center door. A portion of the building between the center and end pavilions is divided into three sections, each section having three bays containing rolling lift doors, 16 feet wide and 24 feet high. Between each section are pairs of bays, each pair having a central rolling lift door 16 feet by 24 feet, and two side windows. The bays containing the side windows are 10 feet wide, with long and narrow windows.

The cornice extends the entire length of the building at a uniform level, except at the center and end pavilion, where it is raised five feet, and is finished with a blocking course placed on the top. Between the top of the metal doors and the cornice there are placed steel frame windows 16 feet wide, with ventilating panels hinged at the upper side and 7 feet long. The ventilating panels are connected with a pulley and cord for operating from the floor level. In order to break the monotony of the upper line of windows, a blank wall is shown between the cornice and the doors at 10-foot bays, carrying long, narrow windows. The lighting area is about 15 per cent of the total wall area and the ventilating area about $2\frac{1}{2}$ per cent. The parapet wall is a 6-inch reinforced concrete slab, supported by reinforced concrete columns designed as extensions above the steel supporting columns of the roof. The cornice is to be built of metal lath and plaster on wrought iron forms. Ventilation is provided by means of center pivoted sash 2 feet 6 inches high by 6 feet wide in the center of each of the large windows over the doors. The two elevations, one facing the roadway and the other facing the harbor, will be similar in all respects.

The end elevations are divided into three bays, the center bay having two rolling left doors with dividing mullion. The other two panels have windows, the treatment being similar to the end panel on the side elevation. The center doorway will be surmounted by a blank wall and will have a high cornice with horizontal top. Offices will be provided in each corner of the building to be utilized for employees, for temporary storage of special valuable merchandise and for fire protection equipment. The exterior walls will be finished in pebble dash, rough cast, except the cornice, which will have a smooth finish.

Materials and Class of Construction.

All portions of the wharf and wharf shed are to be constructed as nearly permanent as the present art of engineering will permit. All structural materials are to be steel and concrete, and finishing materials are to be the best of their various kinds in order that the maximum efficiency may be obtained with the least possible future output for maintenance and reconstruction. Structures of this type will be essentially permanent and should require little renewal cost within a period much exceeding the life of the bonds. The maintenance and operating cost will also be reduced to a minimum and will enable very economical handling of cargo, with little operating expense to be met by either shipper or city.

Special attention is paid to making the structures thoroughly fireproof, in order that there may be little risk to the city; that insurance rates may be a minimum, and that the danger from fire to cargo temporarily stored on the wharves, or to railroad rolling stock, or to ships alongside, may be made as small as possible. No combustible materials are used in the construction: material, such as steel, liable to be damaged by burning, and materials stored on the wharf are thoroughly protected by a covering of concrete. In addition to this, electric underwriters' fire pumps are installed in the building for pumping salt water from the adjacent channel, with a complete system of piping for fire fighting purposes, including Siamese hose connections both inside and outside the building in both front and rear at intervals not exceeding 100 feet.

Design of Sub-Structure. (Plate 7.)

The most serious problem in the design of the outer wharves is that of retaining the mud fill back of the bulkhead line. In cases along the San Francisco water front, with foundation materials comparable, where piers are located, and it has been necessary to construct an independent sea wall, the cost has been from $150 to $200 per lineal foot. The design adopted for the proposed wharf consists of two parallel rows of heavy reinforced concrete sheet piling 12 inches thick, supporting the inner and outer edges of the wharf deck and designed to resist the lateral pressure of the mud and to retain it so that 30 feet of water can be provided at low tide immediately off the edge of the wharf. The inner row of reinforced concrete sheet piling will be 40 feet in length and will retain the mud fill for a vertical distance of 10 feet, from elevation 10 to elevation zero. The outer line of sheet piling will be

60 feet in length and will retain the mud fill from elevation minus 20 to elevation of the channel alongside the wharf, which it is proposed at present to dredge to minus 24 feet, and ultimately to minus 30 feet. The corresponding depths of mud fill to be retained by the outer row of sheet piling will be 4 feet and 10 feet. Between the two lines of sheet filing the mud fill will lie on a slope of one on 4½. The bearing piles underneath the main body of the wharf will also resist lateral pressure from the mud fill, but this is depended on only as an additional factor of safety. The two lines of sheet piling will be tied together and to the bearing piles of the wharf by means of the wharf deck and by horizontal lines of struts at each pile bent 13 feet below the wharf deck or at elevation zero. The sheet piling will be tied together longitudinally by reinforced concrete waling pieces placed in the plane of the lower strut system at elevation zero, and in the plane of the wharf deck at elevation 13 by the system of beams and girders. Each end of the wharf deck is also composed of reinforced concrete sheet piling. This method of construction will provide a continuous row of sheet piling around the periphery of the wharf, forming with the reinforced concrete deck an inverted box inclosing the mud slope underneath the wharf and perfectly protecting it from wave wash. The reinforced concrete sheet piles will be 12 inches square, reinforced with eight three-quarter inch square bars and provided on each side with semi-circular grooves, designed to be filled with cement grout after the piles are driven, thus insuring a watertight structure. They will be separately moulded and allowed to thoroughly season before being driven. They are provided with a 2-inch pipe in the center to facilitate getting them into place. The entire structure is to be built of reinforced concrete piles, beams and slabs. The piles are spaced 10 feet on centers in each direction, except under the railway track, where rows are placed directly under the rails and at the outer row of the columns supporting the shed, where the loads require two rows of piles, spaced four feet apart. The bearing piles will be 70 feet long and 16 inches square for the upper portion of their length tapering to six inches square at the bottom. They will be reinforced with eight three-quarter inch square twisted bars set in a 12-inch circle and tied together with a helical wrapping of one-quarter round steel wire. The penetration of the piling will be about 30 feet, which will take them well into the hard clay foundation material. The standard floor beams of the wharf deck will be 10 by 18 inches rectangular concrete beams, reinforced with five three-quarter inch square bars. The beams

carrying the railroad track and building walls, designed for heavy loading, will be of reinforced concrete 14 by 36 inches, and 12 by 30 inches, reinforced with eight seven-eighths inch square bars and six three-quarter inch square bars respectively. All beams are to be designed as continuous, with rods running over the pile supports to provide for negative bending moments, and are to be reinforced for shearing stresses by bending up rods diagonally at the ends and by providing loops and stirrups. The floor slabs are to be 6 inches thick of concrete, reinforced in each direction with one-half inch square bars on nine inch centers. The paving will consist of two inches of fine graded asphaltic macadam or asphaltic brick, except for the space between and adjacent to the track rails on the outside, which will have wooden blocks on sand cushions, to permit of repairs or renewals to the tracks. The wharf deck beams and girders and piles are designed for a live load of 400 pounds per square foot. The car tracks are designed for Coopers E-50 loading. (See Plate 7.)

Fender Arrangement.

An important part of the design of any wharves, particularly for large vessels, is the arrangement of fenders to prevent injury to the wharves or ships alongside from collisions, or from wave action or impact. The style of fender in ordinary use in wharf construction in San Francisco Bay consists of a line of untreated wooden piles driven into the mud at about 3-foot centers, tied together with three lines of wooden ribbing, and connected with the wharf through car springs set at short intervals to absorb the vessel's impact. This type of fender involves a very heavy cost of maintenance, because the piles are rapidly eaten away by marine borers, necessitating complete renewal at intervals of six months to two years. The design for the Richmond wharf includes the hanging type of fender, such as is now being installed on the new San Francisco piers Nos. 26, 28, 30 and 32, consisting of steel triangles built up with 8-inch H sections hanging from the under side of the wharf beams in cast iron guides, which permit them to slip in and out in resisting the impact of the vessels. The vertical bar of each triangle carries three lines of wood ribbing, longitudinally. The lower is at the low water surface and the upper at the wharf deck. This ribbing is bolted to 10 by 10 inch fender timbers spaced two feet apart on centers and extending from a few feet below the low water to the deck of the wharf. Between the upper line of ribbing and the wharf deck strong car springs are set at

intervals to absorb the impact. In the design for the Richmond outer wharf the car springs are set at 10-foot intervals and opposite the transverse pile bents. The steel triangles are set 10 feet on centers as near to the transverse pile bents as possible, so there will be no bending moment in the horizontal beams. The maintenance is low, as the fender pile extends only a few feet below low water, where the marine animals do little work, and also as the material required to replace the fenders is only about one-fourth of the length of driven piles. To prevent the hanging fender from being caught on the side of vessels moored alongside and torn vertically from the wharf, a raft of four 12-inch timbers should be floated against the fender piles at all times. This line keeps the vessel away from direct contact with the fender piles and prevents any stress being communicated to the fender line as the vessel rises and lowers with the changing tide.

General Plan of Wharf.

The design of the outer wharf has been worked out to accommodate medium sized and light draft river boats, as well as large, deep sea-going vessels. The overall dimensions of the wharf are 801 feet long by 91 feet 3 inches wide. The outer 180 feet nearest Point Richmond is especially equipped for river boats, and the balance is provided with a railway track and designed for use by large vessels.

The wharf shed is set 18 feet 2 inches back from the front of the wharf on the bulkhead line, and is 72 feet 4 inches wide and 742 feet 4 inches long over all. The railway track goes on to the wharf at the inner or easterly end and extends a distance of 620 feet along the wharf in front of the shed. The entire shed floor is available for storage, freight handling and teaming. Teams can come upon the wharf deck at either end of the shed and pass into the shed at the ends, or can pass along the outer side of the shed, if the railroad track is clear. By means of temporary inclines, teams could enter the shed at the center or at any other convenient point. The elevation of the deck of the wharf is about 13 feet. This makes the inner side of the wharf three feet above the street level and permits of easy loading of drays or wagons, or freight cars running along the track at the rear. A railroad track located on the street side is close to the wharf, and is partially covered by a metal awning, so that trucking may be readily accomplished direct from the wharf floor into cars. The three-foot depression of the street level below the wharf floor is intended as a mean of

the most advantageous heights for railway cars and for drays which are 3 feet 8 inches and one foot 6 inches high respectively.

Provision for River Boats.

On the westerly or outer 180 feet of the wharf there are provided two inclined runways with aprons for the accommodation of river boats having lower decks. These runways will be built of reinforced concrete and provided with vertical lift aprons to accommodate any ordinary height of deck of the river boats. One of the runways will be 16 feet wide and one 8 feet 8 inches wide. There is nothing, of course, to pervent river boats from using any other portion of the wharf, as it is not too high for any of the larger boats at any time, nor too high for any of the smaller boats at high tide. The aprons will undoubtedly prove a great convenience, however, as they will eliminate the necessity of using gang planks for trucking.

Structural Design of Wharf Shed.

The wharf shed is a steel frame structure 72 feet by 740 feet with reinforced concrete roof slab and curtain walls. The steel frame is thoroughly tied together and braced in all directions. The roof is designed for a live load of 30 pounds per square foot, with a horizontal wind pressure on the sides and ends of the building of 20 pounds per square feet. The standard spacing of the columns is 70 feet transversely and 20 feet longitudinally. The transverse spacing permits of the unobstructed use of the wharf floor for teaming and freight handling. There are four pairs of 20-foot bays, which have a center column replaced by two columns with 10-foot spacing, making one 20-foot bay in the center, flanked by two 10-foot bays on each side. This special arrangement of columns is necessitated by the architectural arrangement previously described. The spacing of the roof trusses throughout the building is 20 feet. At the special bays having columns on 20 and 10-foot centers, the roof trusses retain their constant spacing, being carried on longitudinal trusses over the doorways. The roof purlins are spaced 11 feet 8 inches on centers and are composed of 15-inch 42-pound I beams. The 4-inch reinforced concrete roof slab rests directly on the steel purlins. The surface is a water proof five-ply composition of felt, tar and gravel. The roof trusses are of the Warren type, with verticals supporting the upper cords and carrying alternate purlins. The upper cord section is composed of two 6-inch by 4-inch by ¾-inch angles. All other members are built of double angle

sections as shown in detail on Plate 7. The roof truss is to be fire-proofed throughout with metal lath on wood furring and protected by at least 2 inches of concrete or cement plaster. It is possible that the recent development of the tool known as the "Cement Gun," by which cement plaster is shot with compressed air directly from a pipe on to lath, will make it possible to fireproof the trusses and other structural steel members without the use of forms or scaffolding.

The main supporting columns of the roof are composed of 12-inch 84½-pound H sections continuous from the floor to the eaves, and supporting in addition to the roof trusses a heavy crane rail bracket 24 feet above the floor for the freight handling apparatus. The columns are supported on a heavy reinforced concrete girder which distributes their load to two piles spaced four feet apart. The base plates of the columns are anchored into this girder. Each transverse bent consists of two columns and a roof truss. All members of the steel frame are to be thoroughly fireproofed with at least 2 inches of concrete outside of any steel. Longitudinal rigidity is given to the building by the X-bracing shown in Plate 7 in six 20-foot bays containing windows, and in the eight 10-foot bays. The rigidity of the roof framing is supplemented by heavy fireproofing on the roof trusses and by a 4-inch reinforced concrete roof slab. The doors of the side elevation are 24 feet high and 16 feet wide, and provided with rolling lift steel shutters, which open vertically and roll on a cylindrical drum, set immediately above the doors between the crane rail girder and the head of the door frames. This height permits the extension arm of the traveling crane to pass through the doorway and to load or unload through hatches in roofs of box cars, and, of course, to handle any material loaded on flat cars at a corresponding height.

The end frames show a doorway in the center 18 feet high and 22 feet wide. These end frames are built in three bays, the center bay being 30 feet wide and the two side bays, each being 20 feet wide. The side bays have X-bracing extending from floor to roof and giving lateral rigidity to the building.

Mechanical Freight Handling Apparatus.

The wharf shed is to be provided with a five-ton traveling crane spanning the full 70 feet between the side columns and traveling the full length of the building. It is to be of the extension arm type, with a carriage designed to handle material a distance of

12 feet outside the building line on either side of the shed. The crane can run the entire length of the building and pick up a load at any point of the building and transfer it to any other point, or to any point within 12 feet of either side of the shed. The crane will be operated by electricity and will be especially useful for loading cars, wagons or trucks at any point of the building or in the street immediately at the rear of the building. The traveling crane can be easily duplicated at any time that conditions warrant. The vertical clearance under the crane bridge is 24 feet, providing about 14 feet clearance under the loading extension of the traveler and giving ample height for handling any loads which are required, either in cars or trucks. The extension arms will make it possible to handle in either direction from cars, either on the depressed track at the rear, or on the level track at the front door of the wharf sheds.

Present Construction.

For the present it is recommended that approximately the outer 550 feet, or slightly over two-thirds of the wharf be built as described in the previous chapter, without the traveling crane.

CHAPTER XV

INNER HARBOR WHARF.

Location.

The location of the inner harbor wharves proposed is at the extreme end of division No. 2, the branch of the Government channel extending to Ellis Landing and on the easterly side of the channel, that is, at the point nearest to the center of Richmond. The marsh land and the shallow water in this vicinity are to be filled with material dredged from the Government and other channels, and the street system extended down to the proposed bulkhead line. The location is extremely well sheltered, being protected by the Potrero hills from west and southwesterly storms, and being entirely in an enclosed inner basin. It will afford an especially good location or harbor for smaller craft. It extends close to the present industrial section of Richmond, and will undoubtedly be the means of developing the land lying between the wharf site and the center of Richmond as an industrial and manufacturing center.

Type of Wharf.

The channel at this point is so narrow that bulkhead wharves can be much more conveniently used than piers. There is ample room in the inner harbor development for a system of piers on the main channel, which is very much wider, so that the sacrifice of berthing room which may be conserved by piers is not a serious consideration, as there is left ample room for all the piers that will probably be required.

Foundations are favorable at this point for the construction of a bulkhead wharf. The earth strata upon which the wharf must be built, consists of a layer of mud, a few feet in depth, overlying hard yellow clay, with thin, alternate strata of sand and gravel. The mud can be excavated beneath the wharf and a permanent sea wall cheaply constructed. As previously explained the problem of affording sufficient storage room at a point which in the initial development is more or less isolated, is of less importance in the bulkhead type of wharf, because the entire area back of the wharf for its full length is in immediate touch with the water front.

Architectural Treatment.

Two units of wharf shed will be constructed, identical in all respects. Each building will be 410 feet long by 63 feet wide. They will be designed in the Renaissance style of architecture. Each will be divided into seventeen bays 24 feet wide. Each bay has a 3-foot pilaster extending to the cornice. All except the two end bays are fitted with rolling lift steel doors 18 feet wide by 24 feet high. Above the doors and under the cornice are two moulded transom bars forming the divisions between the doors, the transom lights and the ventilating panels. Transom windows over each door have steel frames with wire glass. Between the transom window and the cornice are narrow, rectangular ventilating panels made of diamond shape pattern. The cornice is horizontal and continues for three bays, breaking around each pilaster, and at every fourth bay it is carried around in a circular arch. At each fourth bay the ventilating panel under the cornice is also circular. The length of the building is such that there are four groups of three bays each, with the arch bays separating the groups and forming the ends of the building. The elevation facing the channel is in all respects similar to the rear elevation facing the street.

The end elevation of the building is divided into three bays. The center one has two rolling lift doors 11 feet by 18 feet 6 inches high and eleven feet by twenty-two feet high. The larger

door extends down to cover the opening formed by a depressed railroad track. The dividing bar between the two doors is movable. The two end bays contain large windows instead of rolling lift doors and are designed to provide office accommodations at each end of the building. One corner will be devoted to electrically driven underwriters' fire pumps.

The entire building will be constructed of reinforced concrete and the exterior walls will be finished in pebble dash, rough cast, except the cornice, which will have a smooth finish. The architectural effect of the building is heightened by an open basin for smaller craft at the inner end, finished with an open balustrade and pedestal wall along the bulkhead line. This balustrade and wall is broken by four openings with stairways leading to floats for small craft.

Materials of Construction.

The entire structure is to be constructed as nearly permanent as possible. All structural materials are steel and concrete, and all finishing materials designed for the greatest permanency and the minimum cost of maintenance or renewal. The substructure and wharf sheds are of reinforced concrete, thoroughly fireproof. No combustable materials of any sort are used. The structure is fitted throughout with piping for fire protection, connected with underwriters' fire pumps, electrically operated, and designed to pump salt water from the channel adjacent. Fire plugs for Siamese hose connections are placed at intervals of about one hundred feet inside and outside of the wharf shed at the front and rear.

General Plan.

The over all dimensions of the substructure plan or deck are 87 feet 6 inches wide by 1,069 feet long. Upon this deck, wharf sheds are each built 63 feet wide by 410 feet long, and set 24 feet 6 inches from the edge of the deck, along the bulkhead line. The two sheds are separated by a space 200 feet long in the center and are each set 24 feet 6 inches from the extreme ends of the wharf deck. Two railway tracks are provided, passing longitudinally through the length of the structure. One is level with the floor and placed on the open dock outside the shed along the water front. The other is depressed 3 feet 6 inches below the wharf in order to bring car floors on the same level. It passes longitudinally through the structure, dividing the shed into two spaces, one having a clear width of 28 feet 6 inches in the rear,

and the other a clear width of 18 feet10 inches. The railroad tracks are connected by turn outs from the center of the wharf between the sheds to the main track along the water front street. The depressed track is to be bridged at convenient intervals by movable rolling platforms, which can be lifted by the cranes or by hand to permit the movement of cars.

Substructure Design.

The wharf is founded upon concrete piles 16 inches square, with a penetration into the hard clay strata of about 30 feet. Upon these piles is built a reinforced concrete deck supported on reinforced concrete beams and girders. The deck is a 7-inch slab of concrete reinforced in two directions with one-half inch steel bars on 5-inch centers and surfaced in the interior of the shed with paving, as described for the outer wharves. On the water front side of the shed the paving between the various rails is to be wood blocks on a sand cushion to facilitate removal of the track rails. The piling plan shows rows of piles spaced 12 feet apart longitudinally, and from 5 to 12 feet transversely. The main building columns, which are 20 feet apart, are each carried on four piles on five-foot centers, longitudinally, and ten-foot centers transversely. The railway track inside the shed is carried on three pile bents. The railroad track and the portal pier crane tracks outside of the shed have piles at 12-foot centers under each rail. All reinforced concrete piles like those of the outer wharf are to be 16 inches square for the upper three-fourths of their length and taper to 6 inches square at the bottom. They are to be reinforced with eight three-quarter inch square twisted bars set on a 12-inch circle and wound with a helical rapping of one-quarter inch round steel wire. The beams are to have brackets at the pile supports in order to increase the strength and rigidity of the connections. The elevation of the highest point of the finished wharf floor is to be plus 12 feet. In order to secure a pile penetration of about 30 feet in the hard substrata this will require 70-foot piles in the outer rows and 40-foot piles in the inner rows next to the wall.

The sea wall is to be a reinforced concrete retaining wall, supported and held by the inner edge of the wharf floor and founded on wood piles. The bottom of the wall is to be at a depth of 7.8 feet below datum and will rest on a hard clay substrata. The slope of the earth from the base of the sea wall to the channel bottom at elevation minus 20, will all be in hard clay and will be finished at a slope of one on two and two-thirds. The length of the

piling is designed to provide for the ultimate excavation of the channel to a 30-foot depth at low water. The slope will be constructed so that it can be extended at the same angle to the 30-foot depth line. The fill back of the wharves will be finished at elevation 10 and will be retained by the concrete wall and the earth slope under the wharf. This slope will be paved with 3 feet of rip-rap extending underneath the wharf, and in front of the sea wall through the small boat basin at the inner end. The concrete sea wall is to be extended on the inner or city end of the wharf a distance of 300 feet, surmounted by an ornamental balustrade. Four stairways will descend from this wall to landing stages or floats, providing accommodation for tugs or small boats. The paved slope will permit of boats with a draft not exceeding 10 feet at low water using the floats. The maximum load to be carried by the reinforced concrete piles will vary from 30 to 45 tons, depending upon their position under the wharf. The length of piles is intended to maintain safe bearing capacity, even when the channel is dredged to 30 feet in depth and the earth around the outer lines of piles removed. The designing loads are the same throughout as for the outer wharf.

Fenders.

The exposed front of the wharf, at which vessels will tie up, is to be protected from impact by hanging fenders, similar in design to those described for the outer harbor wharves, except that the triangular frames and cast iron guides will be spaced at 12-foot intervals instead of 10. At each of the two outer corners of the wharf a 20-foot pile cluster of creosoted wood piles is to be driven and bound together with steel cable. The outer end of the proposed wharf will in the future be connected with an extension of the concrete wharf, making spring fenders unnecessary and hence cheaper solid wooden fenders are provided.

Structural Design of Wharf Shed.

Each of the two wharf sheds are identical in structure. The plan shows columns spaced 61 feet center to center transversely and 24 feet center to center longitudinally. The columns have a cross section of 14 by 24 inches with pilasters on the outside 36 inches wide and 2 inches deep. These columns carry the roof loads and the loading from the crane rail girders. They have a constant cross section from floor to roof. They are reinforced with four structural steel angles 3 by 3 inches by 5-16 inch, laced to-

gether on the four sides. This design permits of a good bracket being made for the crane rail girder by means of a batten plate and also permits a reliable connection to the reinforcement of the lower chords of the roof girders, which reinforcement also consists of four steel angles laced together on the four sides. The crane rail girder is supported on a concrete bracket, reinforced with two batten plates riveted to the steel angles of the columns.

The main girders carrying the roof are six feet deep at the ends and 8 feet 6 inches deep at the center and 12 inches wide. These girders carry purlins 10 feet 4 inches on centers and spanning 24 feet from center to center of the girders. The purlins are reinforced concrete beams 10 by 20 inches in coss sections reinforced with three seven-eighths inch square bars. They carry a 4-inch concrete slab reinforced with wire mesh. This slab is waterproofed on top, with a composition roofing of 5-ply felt, tar and gravel.

The walls of the building between columns and doors and window headers are to be 6 inches thick, reinforced with three-eighths inch square bars 18 inches on centers both ways. The window sash is to be built of steel, requiring the minimum of width in the wall. The doors are 24 feet high and 18 feet wide and are to be provided with rolling lift steel shutters, which open from a cylindrical roll on a drum set immediately above the door between the crane rail girder and the door head.

The rigidity of the building laterally is insured by the 24-inch depth of columns and the deep reinforced concrete girder with brackets at the column supports. For rigidity in the longitudinal direction, the purlins, the door headers and the crane rail girder in each bay and the two solid bays which have no door openings are depended upon. In the four corners of each shed one-story offices, properly partitioned, are provided for the use of employees using the wharves.

The lighting of the interior is accomplished by means of the windows in the walls. This window area is about 10 per cent of the total wall area and will give good light when all doors are closed. Ventilating of the interior when the doors are closed is provided by means of open ventilators above the window and under the roof in the side walls. The area of the ventilators is about 3 per cent of the total wall area.

In plan the wharf deck has three tracks: two railroad tracks and one portal pier crane track. One railroad track and the portal pier crane track are outside the shed on the wharf deck next to

the channel. These tracks are level with the wharf deck. The other car track, inside the shed is depressed 3 feet 6 inches below the floor so as to permit trucking on a level between the wharf floor and the car floor. This depression for the track is 11 feet 8 inches wide and divides the shed into two areas, the one next to the street being 18 feet 10 inches wide and the one next to the water side 28 feet 6 inches wide inside of columns. The floor of the wharf shed is 22 inches above the street level at the building line, providing for level trucking from drays to wharf floor. It is intended that teams shall come upon the wharf deck at the two ends, and in the center between the sheds, giving an entrance to the shed from both ends to the floor section, which is 28 feet 6 inches wide. When the portal pier crane permits, and the outer car track is clear of cars, teams may also pass along the outside of the wharf shed from end to end.

Mechanical Freight Handling Equipment.

Provision is made for a 5-ton traveling crane, with arms that can be extended laterally through the doorways and a distance of 12 feet outside of the building line. This crane can run the entire length of the building and pick up a load at any point in the building and transfer it to any other point in the building, or to any point within 12 feet of the building line on either side through the doorways. This will provide crane service to freight cars on the depressed track in the building, to freight cars on the surface track on the water front side of the building, and to teams on the street side of the building. It is intended that the cranes shall be operated by electricity. The portal pier crane, which will run the entire length of the wharf for a distance of 1,000 feet, is intended to load and unload vessels which do not have their own freight handling equipment in the shape of derricks and winches and to transfer this freight to freight cars on the track underneath it or to the wharf deck, where it can be picked up by the extension arm of the inside traveling crane.

Present Construction Recommended.

For the present it is proposed to build only one of the two wharf sheds described and one-half of the total substructure, including one-half of the small boat basin and none of the mechanical freight handling apparatus.

CHAPTER XVI

COST ESTIMATES FOR PROPOSED HARBOR IMPROVEMENTS.

Approximate estimates of cost will be made, first, for the complete development as shown on Plate 5, and, second, for that portion recommended under the present bond issue. Unit estimates have been made from a careful study of the costs of similar harbor work in San Francisco Bay. Some of the unit values used are as follows:

Clam shell, dredging work, 10c per cubic yard.

Suction dredging work, 6c per cubic yard.

Rip-rap slope facing, $1.00 per cubic yard.

Reinforced concrete piling and sheet piling, $1.00 to $1.20 per lineal foot in place.

Untreated timber piling, 40c to 50c per lineal foot in place.

Creosoted timber piling, 60c to 70c per lineal foot in place.

Creosoted timbers and sheet piling for bulkheading work, $50.00 per 1,000 board feet in place.

Bolts and spikes for bulkhead work, 3c per lb. in place.

Reinforced concrete, in beams, slabs and girders of wharf decks, $10.00 per cubic yard in place.

Concrete sea wall, $10.00 per cubic yard in place.

Steel reinforcement for concrete, $65.00 per ton in place.

Asphalt paving for wharves, 10c per square foot.

Wood block paving for wharves, 27c per square foot.

Hanging fenders, $13.00 per lineal foot.

Structural steel in wharf sheds, $80.00 per ton in place.

Steel rails, $50.00 per ton in place.

Rolling steel shutter doors, $1.10 to $1.25 per square foot.

Gravel roofing, 7c per square foot.

Portal pier crane, $12,500.00.

Seventy-foot traveling crane, $9,000.00.

Sixty-foot traveling crane, $8,000.00.

All estimates include an allowance of 10 per cent for engineering supervision, legal fees and contingencies.

Estimated Cost of Ultimate Development of Inner Harbor.

Division No. 1—Between Point Richmond and Point Potrero.

11 piers, 160x750 feet each, with 300-foot slips, reinforced concrete and structural steel structures, thoroughly fireproofed, including sheds, mechanical freight handling equipment, sea wall, and dredging of slips at $505,470.00	$5,560,170.00
Belt line railroad with water front street	133,000.00
Outer bulkhead wharf and shed as shown inn detail	387,000.00
Acquisition of land	50,000.00
Total for Division No. 1	6,130,170.00

Division No. 2—Ellis Channel, including Point Potrero.

87½x500 feet bulkhead wharves	$3,356,000.00
Cut or tunnel through Potrero hill	128,000.00
Belt line railroad with water front street	294,500.00
Outer bulkhead wharf and shed as shown in detail	387,000.00
Acquisition of land	17,800.00
Total for Division No. 2	$3,796,300.00

Division No. 3—Inner Harbor Section.

21 piers, each 160x600 feet, with reinforced concrete substructure and sheds, fireproofed throughout including construction of sea wall and dredging of slips, at $392,260	$8,237,460.00
Belt line railroad with water front street	294,500.00
Acquisition of land	100,000.00
Total for Division No. 3	$8,631,960.00
Grand Total for Divisions Nos. 1, 2 and 3	$18,558,430.00

Cost Estimate for Harbor Improvements Proposed under Present Bond Issue.

This estimate includes the acquisition of 802 acres of land as described in detail in Chapter XIII, the construction of 14,900 lineal feet of temporary bulkheading, as described in detail in Chapter XIII; the construction of approximately 545 feet of the

outer wharf, as described in detail in Chapter XIV, and the construction of one unit of inner wharf, as described in detail in Chapter XV.

It does not include the mechanical freight handling apparatus for either the outer or inner wharves. The estimated cost of the proposed improvements is as follows:

Bulkheading $155,200.00
Acquisition of land 158,000.00
Outer wharf 270,500.00
Inner wharf 145,800.00
                                            ─────────────
    Total $729,500.00

PART V

Summary and Recommendations

CHAPTER XVII

SUMMARY.

1st. The essential requirements for a great seaport are a productive, tributary territory, a good natural harbor and adequate improvements, which should be carried in advance of actual necessities.

2nd. San Francisco Bay has to a very marked degree all the requirements necessary for a great seaport, except the provision of ample wharves and piers.

3rd. The commercial development of San Francisco Bay has been rapid and steady. It promises to be greatly accelerated in the future because of the great prospective development of the tributary territory; because of the early completion of the Panama Canal; because of the increase in Oriental trade, and because of the tendency to concentrate commercial developments.

4th. The commerce entering the Golden Gate is being distributed among a number of minor ports, besides San Francisco. The facilities of San Francisco are inadequate, so that the future increase should go to whatever points on San Francisco Bay provide the best and cheapest terminal facilities. There is ample opportunity for such other developments.

5th. Richmond is a new city of about 12,000 inhabitants, located on the northeastern shore of San Francisco Bay and occupying the broadest portion of the plain bordering the landward side of the bay. The total area of the city is about 27 square miles, of which about one-half is submerged. The topography is diversified, consisting of three general sections as follows: A hilly section adjoining the water front; a low-lying or marshy section, and a section in the rear of high plain lands and hills.

6th. The water front of Richmond is about 18 miles in length, consisting of three sections: First—about four miles along the San Pablo marsh. Second—about eight miles in front of the hilly portion of the city. Third—about six miles on the south on a shallow and somewhat protected basin. In this last section is located the proposed Government Harbor Improvement Project, extending well up toward the center of the city.

7th. Richmond's position with reference to the entrance of San Francisco Bay is more favorable for harbor development than of any other city on the eastern side of the bay. It is relatively close to the Golden Gate to which it is connected by two main channels one having a minimum depth of thirty feet and the other a minimum depth of forty feet. A good thirty-foot channel could be obtained direct to the Richmond water front by a small amount of dredging around the south end of Southampton Shoal.

Government harbor lines are fixed so as to readily permit of extensive harbor development. Destructive winds are practically unknown.

8th. Richmond has rapidly developed as an industrial section. It already contains many large industrial concerns such as the Standard Oil works, California Wine Association plant, Pullman car shops, Santa Fe Railroad shops and a number of large rock quarries.

9th. The growth of Richmond has been on a sounder and more substantial basis than that of most California cities. Large American cities owe their rapid rate of growth to the development of manufacturing. Richmond is one of the few cities in California which has enjoyed industrial development. Its many special advantages for such development promise to make it one of the great manufacturing centers of the state.

10th. Richmond has a city government well adapted for the construction and operation of any public utilities such as harbor works, which might be built or acquired by the city. The assessed valuation is such that it is legally possible to create a bonded indebtedness of about $740,000 for harbor works and about $1,860,000 for all purposes. For a bonded indebtedness of $1,000,000, the present tax rate for bond purposes only would be about 54c, decreasing to about 20c in 1920. For harbor purposes 5 per cent 40-year bonds should be issued.

11th. Richmond's water front has already been partially developed by private interests with temporary construction. The city is laid out so that all of the principal traffic lines focus near the city hall.

12th. A Government project has been recommended which will create a large interior basin in a sheltered area, reaching well up toward the industrial center of the city and extending from Point Richmond around Point Potrero to Ellis Landing and eastward nearly to Point Isabel. At present 20 and 24 feet of water is to be provided at different parts of the project. This may be

later extended to 24 and 30 feet. The harbor will be sheltered and the channels protected from silting by dikes and training walls which will create a tidal basin. The excavation of the channels and basin will provide a large amount of material which can be economically used in the reclamation of adjacent submerged and marshy lands.

CHAPTER XVIII

RECOMMENDATIONS.

1st—Ultimate Proposed Development. It is recommended that a comprehensive plan be at once adopted for the orderly development of the harbor provided by the Government plans in order that all work performed might be a useful and integral part of the final scheme. This plan should provide for the construction of a bulkhead wharf and 11 deep water piers, 160 feet by 750 feet, separated by 300-foot slips, all in the outer division of the harbor between Point Richmond and Point Potrero. A continuous bulkhead wharf should be provided around the second division or Ellis Landing section. Twenty-one piers, each 160 feet by 600 feet and separated by 300-foot slips should be provided along the northern edge of the interior basin, or division No. 3 of the harbor. All harbor work should be designed for the ultimate provision of 30 feet of water at low tide. A belt line railroad and 150-foot highway should be provided around the harbor, and passing along the rear edge of all wharves or piers. The city should acquire all of the submerged lands which will be reclaimed by the dredging of the harbor, and should reclaim and develop such land for manufacturing and industrial purposes.

A project as outlined will provide the city with about 600 acres of reclaimed land for industrial and manufacturing purposes, and with a total of about 9.8 miles berthing room, or sufficient to provide for an annual commerce nearly equal to that of San Francisco at present.

The ultimate cost of this entire project is estimated as follows:

Division No. 1.............................. $6,130,170.00

Division No. 2 .... 3,796,300.00

Division No. 3 .... 8,631,960.00

Total $18,558,430.00

2nd—Present Proposed Development.

For the present it is recommended that wharf construction be commenced simultaneously at both outer and inner ends of the proposed Government Harbor Project. The outer wharf when complete should consist of a bulkhead wharf about 800 feet long and 90 feet wide. The outer 550 feet of this should be constructed at the present time. It should be designed for the accommodation of deep water ships, and as a convenient port of call for river traffic. The inner wharf should be 535 feet in length and should have a 150-foot extension for small boats and tugs. Both wharves should be of the most permanent and substantial construction ,fireproofed throughout, of pleasing appearance and designed to be ultimately provided with mechanical freight handling apparatus. These requirements will provide a structure in which cost of maintenance and renewal will be exceedingly small, and in which the operating cost and port charges for handling cargo will be a minimum.

The city should immediately acquire sufficient submerged land around the edges of the Government Project to receive the material dredged from the channels. It should also acquire submerged land for rights-of-way for the Government dike and training wall and should deed this land to the Government prior to the beginning of the harbor construction. The total amount of land required for both these purposes is about 802 acres. In order that these lands may be reclaimed, the city should at once construct a temporary bulkhead around the channel edge of the land.

The estimated cost of the work, as recommended above for immediate completion, is as follows:

Bulkheading	$155,200.00
Acquirement of land	158,000.00
Outer wharf development	270,500.00
Inner wharf development	145,800.00
Total	$729,500.00

Appendix No. I

Topography of San Francisco Bay

Topography of San Francisco Bay

Entrance.

San Francisco Bay is about 40 miles long and varies from 3 to 10 miles in width.

The entrance is through the channel, widely known as the "Golden Gate," about 3 miles long and nearly one mile wide at its narrowest point. The depth of water in this channel is from 108 feet to a maximum of 360 feet. It is flanked on the north by the high rocky hills of the Marin coast, and on the south by the northern water front of the City of San Francisco, with rocky cliffs on the western half and a narrow rim of partially improved water front on the eastern half. About 5 to 6 miles off the entrance is a semi-circular bar with a center depth opposite the Golden Gate having a least depth of 33 feet at low tide. Along the north shore is the Bonita Channel, with a minimum width of about 1,650 feet and a depth of 45 feet, and along the south shore is the South Channel, with about the same minimum width and a minimum depth of 37½ feet.

Tide and Wind Conditions.

The tidal range in San Francisco Bay is quite uniform and comparatively small, seldom exceeding 5 or 6 feet and reaching a maximum at different points of 7 to 9 feet. The sequence of tides is such that in general the most rapid rate of change is on the falling or ebb tide, so that the ebb tide currents have the greatest velocity and scouring or transporting power. Prevailing winds are discussed in Appendix No. IV.

Area and Channels.

The total area of San Francisco Bay, with its northern extension of San Pablo Bay, is about 420 square miles. In this total there is about 26 square miles of anchorage, with depths of 40 to 90 feet, practically all of which is in the main portion of the bay. Most of the northern extension of San Pablo Bay is relatively shallow, but the Government is maintaining through it a channel with a 500-foot bottom width and a 30-foot depth at low tide.

On Plate No. 2 are indicated the principal navigable channels through San Francisco Bay. Channels having 40 feet in depth, or

the maximum requirements for the largest ocean going ships, are found in the Bonita entrance through the Golden Gate, and through the central portion of San Francisco Bay, from Richmond on the north to San Bruno Point on the south. Deep water channels are also maintained by jetties and dredging through San Pablo Bay to Vallejo and Carquinez Straits, and through the Oakland estuary into the inner harbor. At other points the main channel is narrow and the water shoals rapidly though minor channels adapted for shallow draft boats extend to all important points around the bay.

Shore Line.

The total length of shore line in the main portion of San Francisco Bay is about 100 miles, and of San Pablo Bay about 60 miles. A considerable portion of this is very shallow water and is continuous with tidal flats and tidal marshes. In general, it is only at projecting points or narrow places that deep water is found close to the shore. Over the major portion of San Francisco Bay and over practically all of San Pablo Bay water 25 feet in depth is found only in artificial channels or at a distance of 1 to 2 miles from shore. Table No. 1 shows the width of shoal water at various points of the bay with the distance off shore to certain given depths. In general the shore line is advancing, as the bay is slowly silting up, due to natural agencies which have been greatly accelerated by reclamation and other developments. The main channels are kept scoured under natural conditions by tidal currents. Rapid silting in recent years has been caused in part by the increased amounts of material brought down by the rivers, due to hydraulic mining and to deforestation and cultivation of the foot hills and mountains, and due also in part to the fact that the strength of the tidal currents has been greatly reduced by the reclamation of extensive areas, which, under normal conditions, were flooded and drained at each change of tide.

In the central and northern parts of San Francisco Bay are numerous high, rocky islands, mostly owned by the U. S. Government, and generally surrounded by deep water, affording very convenient places for lighthouses and fortifications. A number of other small islands or sunken rocks have been removed by the Government Harbor Improvement Board in the interest of navigation.

Adjacent Waterways.

San Pablo Bay is a logical extension of San Francisco Bay to the northward. The upper end of San Pablo Bay is connected by the deep narrow Carquinez Straits, about 8 miles long, to Suisun Bay, which is a broad expanse of water with an area of about 20 square miles. At the eastern end of Suisun Bay are the mouths of the Sacramento and San Joaquin Rivers, which are connected to Carquinez Straits by a narrow channel through Suisun Bay maintained with a minimum depth of at least 12 feet. The Sacramento River is navigable for about 250 miles from its mouth at the upper end of Suisun Bay to Red Bluff. Regular service is maintained throughout the year for the first 200 miles to Chico landing. In the lower 60 miles from Sacramento down the Government maintains a 7-foot minimum depth, and the river is used by at least three competing steamer lines, some of which make regular daily round trips with high-class passenger boats. The San Joaquin is always navigable and is much used for the first 40 miles to Stockton, and occasionally to Firebaugh's 100 miles further up. Besides the Sacramento and San Joaquin Rivers there are entering into San Francisco Bay or its extensions the navigable channels of Suisun Creek, Mare Island Straits, Napa River, Petaiuma Creek, Oakland Estuary, Alviso Slough, Coyotte Creek and Redwood Creek.

Improvements Around Bay.

The tidal marshes surrounding much of San Francisco Bay are continuous with a narrow plain which is generally backed by steep, high hills, especially on the east side. Much of this narrow plain, particularly in the central portion of the bay, has already been highly developed as a residence and manufacturing district. The City of San Francisco itself has been built upon a rocky peninsula immediately south of the Golden Gate, with most of its developments on the east or bay side of the peninsula, sheltered somewhat from the ocean winds. Opposite the Golden Gate and forming one continuous and thickly settled district about 20 miles in length on the east side of the bay are the cities of Richmond, Albany, Berkeley, Piedmont, Emeryville, Oakland, Alameda, San Leandro and Hayward, with a population totaling about 235,000 in 1910. On the north side of the Golden Gate, on the Marin hills, are the residential cities of Sausalito, Belvedere, Tiburon, Mill Valley, Corte Madera, Larkspur, San Rafael and San Quentin. Around

the southern shore of the bay from San Francisco southward are South San Francisco, Burlingame, San Mateo, Redwood City, Palo Alto, Alviso, Milpitas, Newark, Alvarado and Haywards, and around the northern edge of the bay are San Pablo, Giant, Pinole, Hercules, Crockett, Port Costa, Martinez, Bay Point, Benicia, Vallejo and the Mare Island Navy Yards, while connected to San Francisco by navigable channels are Petaluma, Napa, Suisun, Rio Vista, Sacramento, Antioch and Stockton, and the towns of the upper Sacramento and San Joaquin rivers, all of which have a more or less important water-borne trade.

Table No. 20—Widths of Shoal Waters, San Francisco Bay.

Point	Distance off	Shore	Depth
S. P. Alameda Mole	11,550 ft.	2.20 miles	12
S. P. Oakland Mole	6,600 ft.	1.25 miles	12
Key Route	16,500 ft.	3.10 miles	20
Emeryville	17,820 ft.	3.37 miles	20
Berkeley	23,760 ft.	4.50 miles	20
Pt. Isabel	19,660 ft.	3.72 miles	20
West Alameda	9,240 ft.	1.75 miles	20
Center of Alameda	16,500 ft.	2.12 miles	20
Bay Farm Island	13,860 ft.	2.63 miles	20
Pt. Richmond	1,660 ft.	0.31 miles	20
Pt. San Pablo	100 ft.	0.02 miles	20
Pt. Visitation	10,000 ft.	1.89 miles	20
Candlestick Pt.	6,600 ft.	1.25 miles	20
St. San Bruno	9,700 ft.	1.83 miles	20
Hunters Pt.	150 ft.	0.03 miles	20

Climatology of San Francisco Bay Region.

The climate of the San Francisco Bay region is remarkable in many ways, especially in the great uniformity of temperature. The mean annual temperature at San Francisco is about 55 degrees or practically the temperature of the Pacific Ocean at this latitude. The coldest month is January, with a mean temperature of 49 degrees. The warmest period of the year is the latter half of September and the first half of October, when the mean temperature is about 59 degrees. The highest temperature ever recorded is 101 degrees and the lowest 29 degrees. The very small range is accounted for by the proximity of the Pacific Ocean and by the high

fogs in the summer time. Thunder storms are practically unknown and a fall of snow is very rare and never remains for more than a few hours.

Rainfall.

The greatest portion of the rainfall occurs in the months from October to April, inclusive. The summer months of June, July and August are practically rainless. During a period of sixty years the average rainfall has been about 23 inches, with a minimum of 9.31 inches and a maximum of 38.82 inches. The seasonal rainfall shows a somewhat greater variation, the minimum being 7.42 inches and the maximum 49.27 inches. The maximum rainfall is 24.36 inches. The average number of rainy days per year is 71, or less than 20 per cent.

Humidity.

The average humidity is shown by the following table:

Table No. 21—Average Humidity of the San Francisco Bay Region.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
8 a. m..	87	86	85	85	87	89	92	93	88	86	85	84	88
8. p. m..	75	72	70	69	72	72	77	79	73	71	71	73	73

On the west side of the Bay at Berkeley the average precipitation is about 12 per cent higher and the average temperature is slightly higher. The temperature also has a slightly greater range.

Data on winds is discussed in full in Appendix No. IV.

Appendix No. II

Forecast of Population and Wealth of San
Francisco Bay Region

Forecast of Population and Wealth of the San Francisco Bay Region

Scope of Investigation.

The main purpose for which this investigation was undertaken is the forecasting of the future wealth and population of the cities and counties bordering San Francisco Bay. The results should help to enable a more rational estimate to be made of the probable requirements of the various cities for harbor development and other public improvements, as well as their ability to finance such undertakings. Estimates will be made for the following segregations:

1. San Francisco.
2. Alameda.
3. Richmond.
4. Oakland, Berkeley and vicinity, including Oakland, Berkeley, Albany, Piedmont and Emeryville.
5. Greater San Francisco, including Richmond, Albany, Berkeley, Piedmont, Emeryville, Oakland, Alameda and San Leandro, San Francisco, South San Francisco and Colma.
6. The Bay Counties, including the counties of San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma and Marin.

General Methods of Forecasting Wealth and Population.

There are two general methods in use for forecasting wealth and population:

Method No. 1—By comparison with the rates of growth of similar cities of greater population.

Method No. 2—By a study of the past rates of growth of the city under consideration.

The conditions which effect a city's growth are so numerous and so intricate that it is impossible to predict the future with any degree of certainty, and inadvisable to attempt such prediction for more than 40 or 50 years in advance. Under American conditions particularly the growth of different cities at the same time as well as the growth of any one city at different times varies so widely that only very approximate estimates are possible.

The first method is usually employed in forecasting for the longest time in the future, although if applied to any large city in America it will be found that the growth of American cities has been so recent and so rapid that there are so few cities the growth of which it is possible to study for 40 or 50 years that a good average can not be obtained.

The second method of forecasting is usually limited to not over one or two decades in the future. This is because the rate of growth of any given city changes so much with its size and with local conditions that better results can be obtained for longer periods by observing the rates of growth of other cities similarly located, and at the time they were of similar size.

FORECAST OF FUTURE POPULATION.

Sources of Information.

The most comprehensive and reliable data which can be obtained for population studies are the reports of the U. S. Census Bureau. These are published every ten years and give the population of political subdivisions for the years of the even decades. Other data which give a more or less reliable index of population can be obtained from school census, school enrollments, registration of voters, number of births and deaths, number of marriages, and particularly in cities, the number of names in the city directories, the number of telephone subscribers and the number of connections to city water supply systems. In order to obtain an estimate of population from any of this data it is necessary to estimate certain multiplying factors. The most reliable results can be obtained from the school census, the school enrollment, the registered voters and the number of names in the city directories.

Forecast of Population by Comparison With Other Cities. (Method No. 1.)

Data has been compiled from the U. S. Census reports, and is given in the following table No. 22, showing the growth and population of the larger American cities from the year 1800 to the year 1910:

Table No. 22—Population of American Cities.

Cities	1800	1810	1820	1830	1840
Albany	5,349		12,630	24,209	33,721
Baltimore	26,514	46,555	62,738	80,620	102,313
Boston	24,937	33,787	43,298	61,392	93,383
Brooklyn	2,378	4,402	7,175	12,406	36,233
Buffalo			2,095	8,668	18,213
Cambridge	2,453	2,323	3,295	6,072	8,409
Charleston	18,824	24,711	24,780	30,289	29,261
Chelsea	849	594	642	771	2,390
Chicago					4,470
Cincinnati			9,642	24,831	46,338
Cleveland				1,076	6,071
Columbus				2,436	6,048
Detroit			1,422	2,222	9,102
Elizabeth		2,977	3,515	3,455	4,184
Elmira			2,945	2,892	4,791
Indianapolis					2,692
Jersey City					3,072
Louisville			4,012	10,341	21,210
Milwaukee					1,712
Newark		8,008	6,507	10,953	17,290
New York	60,515	98,373	123,706	202,589	312.710
Patterson					7,596
Philadelphia	41,200	53,722	63,802	80,462	93,665
Pittsburg		4,768	7,248	12,568	21,115
St. Louis					16,469
Washington			13,247	18,826	23,364

From Table No. 22 has been constructed Diagram No. 5, Appendix No. II, showing graphically the growth and population of the larger cities of the country from the years 1800 to 1910. The curves representing the several cities stand apart from each other and show the comparative size of each of the cities at each decade. The slope of the curves also shows the relative rates of growth. They have been drawn between census years as straight lines, assuming that the population increased at a uniform rate during each decade. This is a condition which rarely exists, but for periods extending over a long term of years, curves plotted in this way show the relative population and rates of growth with sufficient accuracy for comparative purposes.

Table No. 22 (Continued)—Population of American Cities for Census Years.

Cities	1850	1860	1870	1880	1890	1900	1910
Albany	50,763	62,367	69,422	90,758	94,823	94,151	100,253
Atlanta	2,572	9,554	21,789	37,409	65,533	89,872	154,839
Baltimore ...	169,054	212,418	267,354	332,313	434,439	508,957	558,485
Birmingham ...				3,086	26,178	38,415	132,685
Boston	136,881	177,840	250,526	362,839	448,477	560,892	670,585
Brooklyn	96,838	266,661	396,099	566,663	806,343		
Buffalo	42,261	81,129	117,714	155,134	255,664	352,387	423,715
Cambridge ...	15,215	26,060	39,634	52,669	70,028	91,886	104,839
Columbus ...	17,882	18,554	31,274	51,647	88,150	125,560	181,548
Charleston ...	42,985	40,522	48,956	49,984	54,955	55,807	58,833
Chelsea	6,701	13,395	18,547	21,782	27,909	34,072	32,452
Chicago	29,963	109,260	298,977	503,185	1099,850	1698,575	2185,283
Cincinnati ..	115,436	161,044	216,239	255,139	296,908	325,902	364,463
Cleveland ...	17,034	43,417	92,829	161,096	261,353	381,768	560,663
Detroit	21,019	45,619	79,577	116,342	205,876	285,704	465,766
Denver		4,749	4,759	35,629	106,713	133,859	213,381
Duluth		80	3,131	3,483	33,115	52,969	78,466
Elizabeth ...	5,583	11,567	20,832	28,229	37,764	52,130	73,409
Elmira	8,166	8,682	15,863	20,541	30,893	35,672	37,176
Galveston ...	4,177	7,307	13,818	22,248	29,084	37,789	36,981
Indianapolis ...	8,991	18,611	48,244	75,056	105,436	169,164	233,650
Jersey City...	6,856	29,226	82,546	120,722	163,003	206,433	267,779
Kansas City ...		4,418	32,260	55,785	132,716	163,752	248,381
Lorain				1,595	4,863	16,028	28,883
Los Angeles ...	1,610	4,385	5,728	11,183	50,395	102,479	319,198
Louisville ...	43,194	68,033	100,753	123,758	161,129	204,731	223,928
Milwaukee ...	20,061	45,246	71,440	115,587	204,468	285,315	372,857
Minneapolis ...		2,564	13,066	46,887	164,738	202,718	301,408
Newark	38,894	71,941	105,059	136,508	181,830	246,070	347,469
New York ...	515,547	813,669	942,292	1206,299	1515,301	3437,202	4766,883
Omaha		1,883	16,083	30,518	140,452	102,555	124,096
Paterson	11,334	19,586	33,579	51,031	78,347	105,170	125,600
Portland	821	2,874	8,293	17,577	46,385	90,426	207,214
Philadelphia . .	408,702	565,529	674,022	847,170	1046,964	1293,697	1549,008
Pittsburg	46,601	49,221	86,076	156,389	238,617	321,616	533,905
Salt Lake City.		8,236	12,854	20,768	44,843	53,531	92,777
Seattle			1,107	3,533	42,837	80,671	237,194
South Bend ...	1,652	3,832	7,206	13,280	21,819	35,999	53,684
St. Louis	77,860	160,773	310,864	350,518	451,770	575,238	687,029
St. Paul	1,112	10,401	20,030	41,473	133,156	163,065	214,744
Tacoma			73	1,098	36,006	37,714	83,972
Washington ...	40,001	61,122	109,199	177,624	230,392	278,718	331,069

Table No. 23 has been compiled principally from U. S. census reports and shows the growth in population of the San Francisco Bay cities and counties from 1850 to 1910.

DIAGRAM N° 5
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
POPULATION
OF
PRINCIPAL AMERICAN CITIES
1800-1910

SEP 1912

Haviland & Tibbetts
Civil & Consulting Engrs.
San Francisco.
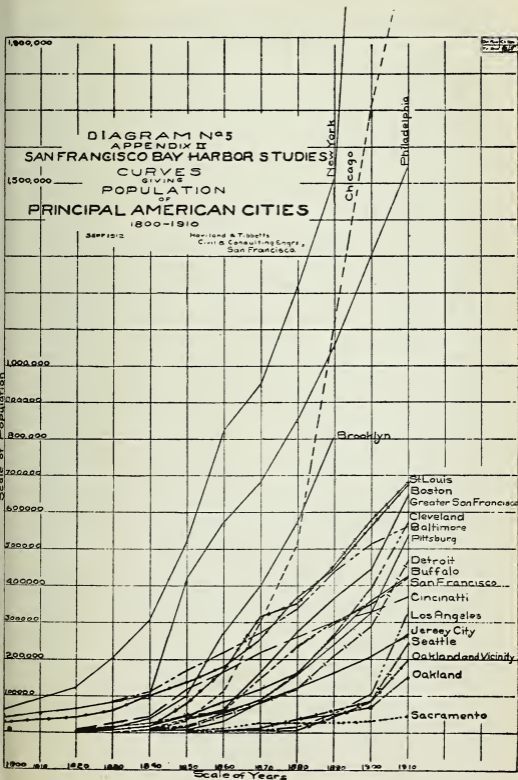
Table No. 23—Population of San Francisco Bay Cities and Counties for Census Years.

Communities	1850	1860	1870	1880	1890	1900	1910
Cities—							
Albany	.....	.....	......	......	......	.....	808
Berkeley	.....	.....	......	......	5,101	13,214	40,434
Emeryville	.....	.....	......	......	228	1,016	2,613
Piedmont	.....	.....	......	......	634	634	1,719
Oakland	1,543	11,104	34,555	48,682	69,960	150,174	
Oakland, Berkeley and							
vicinity	1,543	11,104	34,555	54,645	84,190	195,748	
Richmond	.....	.....	......	......	......	......	6,802
Alameda	460	1,557	5,708	11,165	16,464	23,383	
San Leandro	.....	.....	......	......	2,253	3,471	
East Bay Cities	2,003	12,661	40,263	65,810	102,907	299,404	
S. San Francisco	.....	.....	......	......	......	1,989	
Colma	.....	.....	......	......	......	3,500	
San Francisco 34,870	56,802	149,473	233,959	298,997	342,782	416,912	
Greater San Francisco. 34,870	58,805	162,134	274,222	364,807	445,689	651,805	
Vallejo	.....	.....	......	5,987	6,343	7,965	11,340
Stockton	3,679	10,066	10,282	14,424	17,506	23,253	
Sacramento 6,820	13,785	16,283	21,420	26,386	29,282	44,696	
Counties—							
San Francisco 34,870	56,802	149,473	233,959	298,997	342,782	416,912	
San Mateo	3,214	6,635	8,669	10,087	12,094	26,585	
Santa Clara	11,912	26,240	35,039	48,005	60,216	83,539	
Contra Costa	5,328	8,461	12,525	13,515	18,046	31,674	
Alameda	8,927	24,237	62,976	93,864	130,197	246,131	
Solano 580	7,169	16,871	18,475	20,946	24,143	27,559	
Napa 405	5,521	7,163	13,235	16,411	16,451	19,800	
Sonoma 560	11,867	19,819	25,926	32,721	38,480	48,394	
Marin 323	3,334	6,903	11,324	13,072	15,702	25,114	
Bay Counties 36,738	114,074	265,802	422,128	547,618	658,111	925,708	

From Table No. 23 has been drawn Diagram No. 6, Appendix No. II, showing the comparative population and rates of growth of the San Francisco bay cities and counties. From the data given later in Tables Nos. 12 to 20, Diagrams Nos. 13 to 18, have also been drawn showing the population of some of these cities for the periods between census years.

In order to use the data of Tables Nos. 22 and 23 for forecasting the future growth of the bay cities, it is next desirable to superimpose a selected number of the curves upon the curve of the city whose future is under consideration. This should be done by noting the point on the curve of that city for the last census year (1910) and superimpose on that point the curves of the other selected cities at the time at which their population was the same.

Diagrams have been constructed in this way for the following:
Diagram No. 7, City of San Francisco.
Diagram No. 8, City of Alameda.
Diagram No. 9, City of Richmond.

Diagram No. 10, Oakland, Berkeley and vicinity.
Diagram No. 11, Greater San Francisco.
Diagram No. 12, San Francisco Bay counties.

Placing the curves in the manner shown on the diagrams Nos. 7 to 12 has the effect of starting the growth of the whole set of cities from the same point, that is, at the time at which their populations were equal. In all cases it is at once evident that the curves diverge both before and beyond this point, indicating that the rates of growth are quite different for different cities and hence that no positive forecast can be made by this method of the future population of any given city. An intelligent study of the diagram will, however, give a rational basis for the exercise of judgment in estimating the most probable future population.

The usual method in completing such an investigation is to plot three curves for the future population of the city considered. These are called the probable maximum curve, the probable mean and probable minimum. One way of deriving the probable maximum curve is to take the actual average of the faster growing half of the cities of the group. Another method is to take the average of the percentages representing the maximum rates of growth per decade of each of the cities in the group. By this method each city is taken only once and only at the period at which its rate of growth was the maximum. A curve plotted by the latter method representing the average of the maximum rates of growth per decade of each of the cities for a given period gives a rate which is too high theoretically for the decades farthest in the future and too low for those in the immediate future. This follows from the fact that in very large cities the decennial percentage of increase is less than in small cities, although the actual growth is greater. In the particular case for example shown in Diagram No. 10 for Oakland, Berkeley and vicinity the probable maximum curve represents the average of the highest rates of growth per decade of the eight cities shown between 200,000 and 1,000,000 population. The probable minimum curve represents the average of the lowest rates of growth of the same eight cities per decade between the same limits. The mean curve is the actual mean or average of all the curves shown in the diagram. The curves for the smaller cities, of course, drop out at the point representing their population in 1910. In the case of Buffalo this occurs on Diagram No. 10, 25 years in advance of 1910. The weighted mean giving the most probable future values will now be discussed in detail.

DIAGRAM Nº6.
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
POPULATION
OF
BAY CITIES & COUNTIES
1850-1910

SEPT '912   Haviland & Tibbetts
Civil & Consulting Engr's
San Francisco.

NOTE.

Curve marked 48.9% represents the average of the maximum rates of growth per decade between 400 000 and 2 000 000 population

Curve marked 23.3% represents the average of the minimum rates of growth per decade of the some 8 cities between 400 000 and 2 000 000 population

Mean Curve represents a mean of all city curves on the diagram

The Curves for the smaller Cities drop out of consideration at the point representing their population in 1910

The point on the curve of each City at which its population equalized that of San Francisco in 1910 is superimposed upon the point "P" so that the Scale of years is true for San Francisco only

San Francisco's population was plotted from figures computed as explained in the text of Appendix II

Chicago

Maximum 48.9%

New York

Philadelphia

Mean 23.3%

St. Louis
Boston

Baltimore

DIAGRAM Nº 7.
APPENDIX II

SAN FRANCISCO BAY HARBOR STUDIES

CURVE
GIVING
PROBABLE FUTURE POPULATION
OF
SAN FRANCISCO

METHOD Nº 1 — COMPARISON WITH OTHER CITIES

Sept. 1912

Haviland & Tibbets
Civil & Consulting Engrs.
San Francisco.

Scale of Population

Scale of Years

NOTE
The mean high curve is the mean of the four highest city curves shown in the figure and a probable maximum curve for Alameda

The mean curve is a mean of 8 cities curves

The mean low is a mean of the four lowest city curves shown in the figure and a probable minimum curve for Alameda

The weighted mean curve was plotted from figures computed as explained in the text of Appendix II

DIAGRAM Nº8
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVE
GIVING
PROBABLE FUTURE POPULATION
OF
CITY OF ALAMEDA

METHOD Nº I—COMPARISON WITH OTHER CITIES
Sept 1912   Haviland & Tibbetts
Civil & Consulting Eng
San Francisco

Scale of Population

Scale of Years

NOTE

Curve marked maximum represents the probable maximum growth of Richmond and is the mean of the five highest curves of the Cities Shown

Curve marked mean is mean of all City Curves Shown and represents a probable mean growth of Richmond

Curve marked minimum represents the probable minimum growth of Richmond and is the mean of the five lowest of Cities Shown

The weighted mean curve was plotted from figures computed as explained in the text of Appendix II

DIAGRAM N° 9
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE POPULATION
OF
CITY of RICHMOND
METHOD N°1 ~ COMPARISON WITH OTHER CITIES
Sept. 1912   Haviland & Tibbetts
Civil & Consulting Eng'rs
San Francisco

Seattle   Minneapolis

Cleveland
MAXIMUM
Portland

Oakland
MEAN
Detroit

WEIGHTED MEAN

MINIMUM
Pittsburg
Paterson
Elizabeth
Galveston

250,000

200,000

150,000

100,000

50,000

1800   1810   1820   1830   1840   1850
Scale of Years

Note—
Curve marked 657% represents the average of the highest rates of cities growth per decade between 200,000 and 400,000 population. This curve represents the probable maximum growth of Oakland Berkeley & Vicinity

Mean Curve represents a mean of all city curves on the diagram. The curves for the smaller cities dropping out of consideration at the point representing their population in 1910

Curve marked 274% represents the average of the lowest rates of growth per decade of the same 8 cities between 200,000 and 1,000,000 population. This represents the probable minimum growth of Oakland Berkeley & Vicinity

The weighted mean curve was plotted from figures computed as explained in the Text of Appendix II

DIAGRAM Nº 10
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE POPULATION
OF
OAKLAND BERKELEY
AND VICINITY
INCLUDING
ALBANY PIEDMONT & EMERYVILLE
METHOD Nº 1 COMPARISON WITH OTHER CITIES
Sept. 1912

Haviland & Tibbetts
Civil & Consulting Engrs,
San Francisco

Note:—
Diagram N°7 is a curve plotted from the sums of all the Bay Cities populations forecasted by method N°1, taken from the weighted means of diagrams N°3,4,5,&6 and the smaller towns added Greater San Francisco includes Oakland Berkeley & Vicinity, Alameda, Richmond San Leandro, Colma and South San Francisco.

Note—   DIAGRAM N°8
In forecasting for the years 1920 and 1930 the populations of the group of bay counties in the vicinities of Chicago, New York, Boston, Philadelphia, and Baltimore & Washington were given the same weights as the individual cities were when compared with San Francisco.
For the years 1840 and 1930 the following weights were used:
Chicago Vicinity   30
New York   —   30
Boston   —   15
Philadelphia   —   10
the Chicago curve is assumed to continue on the same slope to 1930.

Combined bay counties include Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara Solano and Sonoma.

DIAGRAMS N°11 & 12
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE POPULATION
OF
GREATER SAN FRANCISCO
AND
COMBINED BAY COUNTIES
METHOD N°1—COMPARISON WITH OTHER CITIES & COUNTIES

Sept. 1912   Haviland & Tibbetts
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San Francisco.

Scale of Years
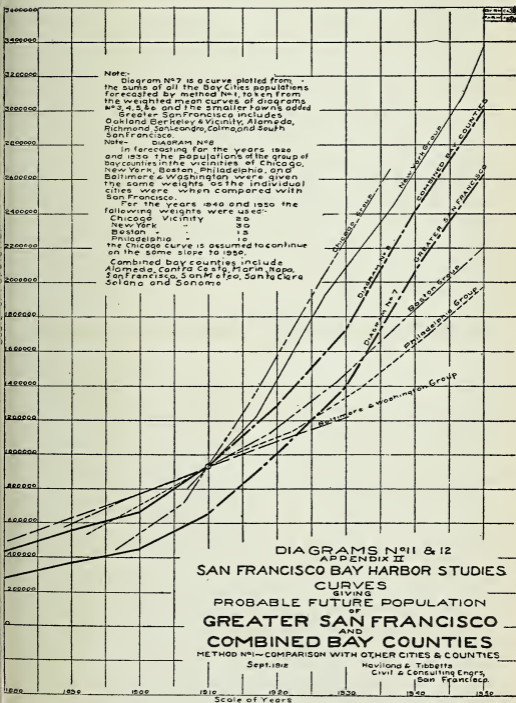
Method of Obtaining Weighted Means of Future Growth.

An attempt has been made to obtain a more probable mean or normal growth than by merely taking the average of the rates of growth of all the cities plotted. It is evident that some members of the group of cities will resemble the one under consideration more than others, and that if more weight were attached to those with the greatest resemblance, a more probable mean rate of growth would be obtained. The first step in this method is to choose a number of cities similar to the one under investigation. A table is next made, showing the principal factors which influence the rate of growth of cities (shown in Table No. 24, Appendix No. II). Some of these factors have a greater influence upon the rate of the cities' growth than the others. The relative importance attached to each of the various factors is shown by the percentage values assigned. These are arbitrary and a matter of individual opinion, but any reasonable variations will leave the final results substantially the same.

Table No. 24—Factors Controlling the Rate of Growth of American Cities.

No.	Factor	Relative Weight Percentage
1.	Commercial resources of tributary territory	20
2.	Water transportation	15
3.	Railroad Communication	15
4	Topography and area	10
5.	Geographical location	10
6.	Climatic conditions	10
7.	Location relative to other centers of population	5
8.	Character of residents and civic spirit	5
9.	Age of city and surrounding country	5
10.	Previous rate of growth	5

For each city whose future is to be forecasted there is next prepared a table describing in detail the local situation in regard to each of the factors controlling the growth of cities as shown in Table No. 24. Tables of this sort have been prepared for the four cities for which a weighted mean is to be determined namely, Table No. 25, for San Francisco; Table No. 26, for Alameda; Table No. 27, for Richmond; Table No. 28, for Oakland, Berkeley and vicinity.

Table No. 25—Characteristics of City of San Francisco Corresponding to the Factors of Table No. 24, Appendix No. II.

1. Large, rapidly developing territory, rich in natural resources and tributary to San Francisco Bay.
2. A seaport on one of the finest harbors in the world, whose commercial growth will be accelerated by the early completion of the Panama Canal.
3. Connected by ferry with the mainland terminals of three transcontinental railroad systems, one coast line railroad system and two electric railroad systems. Two of the transcontinental railroad systems also enter the city by all rail routes. Two all rail suburban electric railroads.
4. Situated upon a peninsula of rolling hills fringed by an area of marsh land on the bay water front. A deep water frontage on land locked bay and the Pacific Ocean. Not as inviting for residential purposes as the surrounding cities.
5. A Western American city. (A rapidly developing section).
6. A mild and equable climate, which renders it possible to keep all lines of communication open throughout the entire year.
7. Contiguous to a large suburban city, Oakland, and other medium sized suburban cities.
8. A cosmopolitan population, a business community somewhat lacking in unity of purpose, and a working population strongly organized in labor unions.
9. City founded and incorporated about the year 1850, coincident with the occupation of California by Americans.
10. Exceptionally rapid growth for the first two decades followed by a rather slow but uniform growth up to the year 1906. Population greatly reduced by earthquake and fire in 1906, followed by a rapid recovery in rebuilding and in population. Rapidly developing environs.

Table No. 26—Characteristics of City of Alameda, Corresponding to the Factors of Table No. 24, Appendix No. II.

1. Large rapidly developing territory rich in natural resources and tributary to San Francisco Bay.
2. A seaport on an island with shallow water on three sides and dredged tidal estuary on the longer side. Commercial growth will be accelerted by early completion. of the Panama Canal.

3. Switching connections with terminal of a transcontinental railroad system. Electric railroad connection with two large adjacent cities.

4. Situated upon a flat island connected with the mainland by five bridges. A large area of partly reclaimed marsh for industrial and manufacturing sites. A restricted highland area being rapidly occupied by the residential section.

5. A Western American City. (A rapidly developing section.)

6. A mild and equable climate, which renders it possible to keep all lines of communication open throughout the entire year.

7. Contiguous to several large cities, including Oakland and San Francisco.

8. A population composed chiefly of business men and workers from the contiguous cities, a business community lacking initiative in promoting home industry. City ownership of the two public utilities and a fixed policy of promoting the domestic welfare of its residents.

9. Vicinity settled about the year 1850 and city incorporated about the year 1872.

10. A steady, rather uniform, but not rapid growth, except for a temporary halt in the last two years.

Table No. 27—Characteristics of City of Richmond Corresponding to the Factors of Table No. 24, Appendix No. II.

1. Large rapidly developing territory, rich in natural resources and tributary to San Francisco Bay.

2. A seaport on one of the finest harbors in the world, whose commercial growth will be accelerated by the early completion of the Panama Canal.

3. The terminal of one transcontinental railroad system and traversed by one other transcontinental railroad system. Electric railroad and ferry connections with two large cities.

4. Situated upon a coastal plain with sufficient area for industrial development. A deep water frontage at the base of a low range of hills, and a shallow water frontage on two sides. Ample area in immediate rear, adapted to residential expansion.

5. A Western American City. (A rapidly developing section.)

6. A mild and equable climate, which renders it possible to keep all lines of communication open throughout the entire year.

7. Contiguous to several other large cities, including San Francisco, Berkeley and Oakland.

8. A cosmopolitan population, composed chiefly of industrial and business people. A business community actuated by exceptional energy, optimism and unity of purpose.

9. City incorporated in 1900 in the vicinity of a large city founded in 1850.

10. Exceptionally rapid growth from a population of nothing in 1900 to a population of about 12,000 in 1912. Rapidly developing environs.

Table No. 28—Characteristic of Oakland, Berkeley and Vicinity Corresponding to the Factors of Table No. 24, Appendix No. II.

1. Large rapidly developing territory, rich in natural resources and tributary to San Francisco Bay.

2. A seaport on one of the finest harbors in the world, whose commercial growth will be accelerated by the early completion of the Panama Canal. Connected with a large city by four ferry lines.

3. The terminal of three transcontinental railroad lines and the subterminal of one other transcontinental railroad line. Electric railroad connections with several suburban cities.

4. Situated upon a coastal plain, with sufficient area for industrial development. Ample area in immediate rear on high lands very desirable for residential expansion. A long frontage of shallow water requiring dredging, partly developed.

5. A Western American City. (A rapidly developing section.)

6. A mild and equable climate, which renders it possible to work out of doors and keep all lines of communications open throughout the year.

7. Contiguous to a larger city and several smaller cities.

8. A population strong and progressive in civic spirit, composed of three elements: 1st. Those supported by local industry and independent incomes. 2nd. Those connected with educational institutions. 3rd. Commuters working in San Francisco.

9. City incorporated in 1860 as a suburb of a large city founded about 1850.

10. A normal rate of growth previous to 1900 followed by a very rapid rate during the past decade.

A list of cities is now chosen to compare with the one under investigation. Each of the cities in this list is carefully considered with reference to each of the factors controlling the growth of cities as shown in Table No. 24. If its situation with respect to each of these factors closely resembles the city whose future is being investigated, then it is assigned the same percentage weight, otherwise it is assigned a smaller percentage as the conditions justify. The sum of the weights of all factors for each city will finally give, as a percentage, the degree of similarity of each of the cities listed with the one under consideration. This total of the weights for all of tne characteristics named is equal to 100 per cent for the city under consideration, and the nearer each of the other cities resembles it, the higher is their percentage weight, always being less than 100. The weighted mean population for any decade is then obtained by using the total weights as multiplying factors; multiplying the population of each city by such factor and dividing the sum of the products by the sum of the factors. The weighted mean curve is then plotted from the population computed as above at each decade. The numerical results obtained by the method described are shown in the following tables Nos. 29, 30, 31 and 32.

Table No. 29—Population Forecast, Weighted Mean, Characteristics. San Francisco.

CITIES COMPARED	WEIGHT OF FACTOR						DEGREE OF SIMILARITY			
Factor of Table 24	1	2	3	4	5	6	7	8	9	10
New York	15	15	15	7	5	5	5	3	0	4	74%
Brooklyn	7	15	10	4	4	5	5	3	2	1	56%
Chicago	18	10	5	2	5	5	0	3	3	4	55%
St. Louis	15	4	10	1	7	8	1	2	2	2	52%
Baltimore	5	8	8	5	3	8	2	4	0	5	48%
Boston	5	10	8	7	2	5	3	3	0	3	46%
Cleveland	7	6	8	4	4	6	0	2	4	4	45%
Philadelphia	10	8	8	3	3	5	2	2	0	0	41%

Table No. 30—Population Forecast, Weighted Mean, Characteristics Alameda.

CITIES COMPARED	WEIGHT OF FACTOR						DEGREE OF SIMILARITY			
Factor of Table 24	1	2	3	4	5	6	7	8	9	10
Oakland	20	15	5	5	10	10	5	3	3	5	81%
Sacramento	10	10	3	5	10	10	0	4	4	5	61%
Jersey City	15	10	7	2	5	5	5	3	1	1	54%
Milwaukee	10	10	3	3	7	5	0	3	4	2	47%
Newark	10	5	5	4	5	5	5	3	2	3	47%
Cambridge .. \	5	0	15	3	2	5	5	4	2	3	44%
Patterson	10	0	10	2	0	5	5	2	2	2	38%
Elizabeth	8	0	8	2	2	5	5	2	2	2	36%

Table No. 31—Population Forecast, Weighted Mean, Characteristics.
Richmond.

CITIES COMPARED	WEIGHT OF FACTOR										DEGREE OF SIMILARITY
Factor of Table 24	1	2	3	4	5	6	7	8	9	10	
Oakland	20	15	12	8	10	10	5	3	3	5	91%
Seattle	15	12	10	10	10	7	2	5	3	5	79%
Portland	15	10	7	7	7	7	7	3	3	3	69%
Galveston	15	12	5	3	8	8	0	4	3	2	60%
Detroit	10	5	6	6	6	6	3	0	4	3	46%
Cleveland	7	6	7	6	4	6	0	4	2	4	46%
Patterson	10	0	8	5	0	5	5	4	0	5	42%
Elizabeth	8	0	8	5	0	5	5	4	0	1	36%
Pittsburg	10	5	7	4	0	3	0	4	0	2	35%
Minneapolis	10	0	5	4	4	3	2	2	1	2	33%

Table No. 32—Population Forecast, Weighted Mean, Characteristics.
Oakland, Berkeley and Vicinity.

CITIES COMPARED	WEIGHT OF FACTOR										DEGREE OF SIMILARITY
Factor of Table 24	1	2	3	4	5	6	7	8	9	10	
Jersey City	15	15	15	7	5	5	5	5	5	5	82%
San Francisco	20	15	5	6	10	10	3	4	4	4	81%
Brooklyn	7	15	10	8	4	5	5	3	3	3	65%
New York	15	15	10	3	5	5	3	2	0	3	61%
St. Louis	15	4	12	6	7	8	0	2	2	0	56%
Detroit	10	5	10	7	6	6	3	0	3	3	50%
Buffalo	10	8	12	6	6	6	3	0	2	1	50%
Cleveland	7	6	10	6	4	6	0	3	2	2	46%
Philadelphia	10	18	10	5	3	5	2	2	0	0	45%
Baltimore	5	5	10	6	2	8	1	1	0	2	40%

NOTE—The percentage of increase of the various cities used in projecting maximum and minimum curves were not weighted as were the percentages used to obtain the weighted mean. Using these weights upon the maximum and minimum percentages would give theoretically better results, but the variation between maximum and minimum curves is so great that such refinements are not considered justifiable. The assumption is made that no catastrophies or unusual stimuli will occur to affect the cities' growth.

This method can best be understood by following it in detail for a particular example, as for San Francisco as shown in tables Nos. 25 and 29. The group of cities selected to compare with San Francisco, arranged in the order of their similarity as finally deduced from Table No. 29, is as follows:

1. New York
2. Brooklyn
3. Chicago
4. St. Louis
5. Baltimore
6. Boston
7. Cleveland
8. Philadelphia

All of these cities were compared with each other and with San Francisco, with reference to factors No. 1 of Table No. 24, "Commercial resources of the tributary territory." San Francisco as stated in Table No. 25 "has a large, rapidly developing country, rich in natural resources and tributary to San Francisco Bay." In Table No. 24 this factor was considered to have more influence upon the rate of growth than any of the other factors considered, and so is given the highest percentage weight, namely 20 per cent. If any of the other cities compared, occupied an exactly similar position with reference to the commercial resources of the tributary territory they would also have been given the maximum rating, or 20 per cent. If their situation in this respect is better or worse, they should be given a lower rate. It was considered that Chicago most nearly resembles San Francisco in this respect, as it is on a system of large lakes controlling the commerce of a large tributary territory, and is in itself in the center of a very large and very rich district. New York and St. Louis come next. New York, with an excellent harbor, but tributary territory on one side only, and St. Louis with little water borne commerce, but with a very rich and rapidly developing territory. Similarly with reference to factor No. 2—"Water transportation"—San Francisco is a seaport on one of the finest harbors in the world. New York and Brooklyn, also on a splendid harbor, are given a rating equal to San Francisco as regards water transportation. Chicago and Boston are second. The percentage for all other factors is derived by comparing each of the cities in turn for each of the factors listed from tables Nos. 29 to 32. The weighted mean curves are plotted as described in diagrams Nos. 7 to 10.

The correction obtained by using the weighted mean, instead of the actual mean ,is not very great, but is believed to give a more rational forecast than could be obtained by the more standard methods. In all cases in this report studies will be based upon the future population as determined by the weighted means, wherever these have been determined.

Forecast of Cities' Population From Studies of Its Past Rates of Growth. (Method No. 2.)

The population of the city under investigation can be directly determined from census records in the years of the even decades, but must be estimated for intermediate years. The best index for such estimates are records of the school census, school enrollment,

registered voters and number of names in the city directory. Figures for these have been obtained from the most reliable sources, covering portions of the period from 1880 to 1912 and are shown in the following tables:

Table No. 33—School Census Reports for San Francisco Bay Cities 1880 to 1912.

Year	San Francisco	Oakland	Berkeley	Alameda	Richmond	Emery-ville	Pied-mont
1880	58,492	......	.....	.....	.....	...	...
1881	55,115	......	.....	.....	.....	...	...
1882	55,880	......	.....	.....	.....	...	...
1883	58,061	......	.....	.....	.....	...	...
1884	63,029	......	.....	.....	.....	...	...
1885	69,000	......	.....	.....	.....	...	...
1886	74,079	......	.....	.....	.....	...	...
1887	78,246	......	.....	.....	.....	...	...
1888	59,517	......	.....	.....	.....	...	...
1889	60,642	......	.....	.....	.....	...	...
1890	61,144	......	.....	.....	.....	...	...
1891	62,456	......	.....	.....	.....	...	...
1892	63,933	......	.....	.....	.....	...	...
1893	65,775	......	.....	.....	.....	...	...
1894	68,390	......	2,209	3,481	.....	208	...
1895	70,006	13,391	2,501	3,330	.....	208	...
1896	71,822	13,283	2,724	3,351	.....	210	...
1897	74,840	13,857	2,825	3,468	.....	369	...
1898	76,336	15,497	2,830	3,460	.....	321	...
1899	75,292	15,993	2,955	3,549	.....	323	...
1900	78,554	16,776	3,193	3,600	.....	342	...
1901	82,173	17,237	3,377	4,063	.....	412	...
1902	82,391	17,730	3,717	4,132	.....	434	...
1903	91,386	17,920	3,910	4,128	.....	432	...
1904	97,353	17,224	4,454	4,078	.....	376	...
1905	98,127	17,316	4,840	4,182	.....	355	...
1906	101,836	19,472	5,331	4,463	.....	358	...
1907	77,367	25,628	6,493	4,752	.....	420	...
1908	87,696	25,038	6,665	4,789	1,830	529	...
1909	88,058	......	.....	.....	.....	...	...
1910	74,729	......	.....	.....	1,831	...	...
1911	......	......	.....	.....	.....	...	...

Table No. 34—School Enrollment Reports for San Francisco Bay Cities.

Year	San Francisco	Oakland	Berkeley	Alameda	Richmond	Emery-ville	Pied-mont
1894	44,349	......	.....	.....	.....	...	...
1895	44,822	......	.....	.....	.....	...	...
1896	45,343	......	.....	.....	.....	...	...
1897	46,564	......	.....	.....	.....	...	...
1898	50,101	......	.....	.....	.....	...	...
1899	48,972	......	.....	.....	.....	...	...
1900	48,058	......	.....	.....	.....	...	...
1901	48,517	11,040	2,530	3,019	.....	217	...
1902	48,893	10,917	2,687	2,855	.....	228	...
1903	48,345	11,087	2,995	2,915	.....	230	...
1904	49,600	11,570	3,367	2,963	.....	230	...
1905	55,067	11,233	3,678	3,084	.....	231	...
1906	57,782	12,608	3,835	3,045	677	262	...
1907	45,633	14,014	4,823	3,528	871	289	...
1908	48,045	13,223	5,316	3,421	1,011	309	...
1909	48,509	14,750	5,327	3,451	963	249	...
1910	50,212	14,622	5,420	3,451	923	245	92
1911	51,462	19,065	5,377	3,178	1,030	267	224

Table No. 35—Names in City Directory, San Francisco Bay Cities.

Year	San Francisco	Oakland*	Alameda	Berkeley	Richmond†
1900	167,000	36,520	7,524	6,405	.....
1901	177,200	40,221	7,684	7,808	.....
1902	182,000	41,630	7,700	8,850	.....
1903	188,700	44,000	8,262	9,152	.....
1904	185,724	48,590	8,100	10,300	.....
1905	187,000	48,230	8,829	12,273	.....
1906	....	75,600	8,700	14,300	.....
1907	148,010	70,115	11,324	15,555	.....
1908	167,676	76,712	11,522	16,378	.....
1909	175,214	78,412	11,848	16,856	3,422
1910	179,280	79,208	10,935	21,520	3,592
1911	183,510	81,200	......	22,542	5,452

*Oakland includes Alden, Allendale, Melrose, Fruitvale, Mills College, Claremont, Temascal, Emeryville and Piedmont.
†Richmond includes San Pablo, Stege and Pullman.
Polk-Husted and Crocker-Langley Directories.

Table No. 36—Registered Voters, San Francisco Bay Cities.

Cities	1900	1902	1904	1906	1908	1910	1911	1912
San Francisco ...	73,683	70,716	81,576	51,633	75,388	75,828	101,736	.....
Oakland	14,548	15,558	16,933	20,032	24,947	26,075	31,228	.....
Berkeley	2,953	3,287	4,392	5,435	8,495	8,135	8,558	.....
Alameda	3,269	3,582	3,770	4,271	4,711	4,472	4,738	.....
Richmond ...	.....	628	570	1,538	1,811	1,656	.....	2,800
Emeryville	569	480	782	999	1,237	1,118	1,140	.....
Piedmont	110	107	125	183	275	345	.....	.....
Sacramento	8,310	8,685	.....	9,171	9,925	10,449	.....	.....

In using any of these tables it is first necessary to find the ratio between the figures contained in the tables and the total population. This can be obtained accurately for census years and can be estimated for intermediate years. It has usually been estimated by interpolation, using the principal of constant second differences. Having obtained the desired ratio for each year the population is found by multiplying the results shown in the tables by the given factors.

This method can best be illustrated by showing its application to a given city, as San Francisco. The following tables, Nos. 37, 38, 39 and 40, show the factors obtained to multiply the results given in tables Nos. 33, 34, 35 and 36 for the City of San Francisco, with the resultant estimated population in the years 1900 to 1910.

Table No. 37—Population of San Francisco, Estimated From School Census Records.

Year	School Census	Factor	Population
1900	78,554	4.36	342,787
1901	82,173	4.50	370,000
1902	82,391	4.64	382,000
1903	91,386	4.77	430,000
1904	97,353	4.90	452,000
1905	98,127	5.02	492,000
1906	101,836	5.14	523,000
1907	77,367	5.25	406,000
1908	87,696	5.36	470,080
1909	88,058	5.47	482,000
1910	74,729	5.58	416,912

Table No. 38—Population of San Francisco, Estimated from School Enrollment Records.

Year	School Enrollment	Factor	Population
1900	48,058	7.13	342,782
1901	48,517	7.26	354,000
1902	48,893	7.39	362,000
1903	48,345	7.52	365,000
1904	49,600	7.65	370,000
1905	55,067	7.77	428,000
1906	57,782	7.89	456,000
1907	45,633	8.00	365,000
1908	48,045	8.11	390,000
1909	48,509	8.21	398,000
1910	50,212	8.31	416,912
1911	51462	8.40	432,000

Table No. 39—Population of San Francisco, Estimated From Number of Names in City Directory.

Year	City Directory	Factor	Population
1900	167,000	2.05	342,782
1901	177,200	2.08	368,000
1902	182,000	2.11	384,000
1903	188,700	2.14	402,000
1904	185,700	2.17	401,500
1905	187,000	2.20	406,000
1906	....	2.23	....
1907	148,000	2.26	335,000
1908	161,500	2.29	370,000
1909	168,800	2.32	392,000
1910	179,300	2.35	416,912
1911	183,500	2.38	437,000

Table No. 40—Population of San Francisco, Estimated From Number of Registered Votes.

GENERAL ELECTIONS				MUNICIPAL ELECTIONS			
Even Registered				Odd Registered			
Year	Voters	Factor	Population	Year	Voters	Factor	Population
1900 ..	73,633	4.65	342,782	1899..	71,786	4.60	330,000
1902 ..	70,716	4.38	341,500	Mean.	74,838	4.58	342,782
1904 ..	81,576	5.00	407,500	1901..	77,890	4.55	453,500
1906 ..	51,633	5.17	266,500	1903..	79,684	4.50	358,500
1908 ..	75,388	5.33	401,500	1905..	98,000	4.45	436,000
1910 ..	75,828	5.50	416,912	1907..	77,601	4.40	341,500
				1909..	90,790	4.35	395,000
				Mean.	96,263	4.33	416,912
				1911..	101,736	4.30	437,500

Data from report of San Francisco Department of Elections, June 30, 1911.

To illustrate the method of obtaining the factors in Table No. 38, for example, the census showed that the population of San Francisco in 1900 was 342,782, and in 1910 was 416,912. In 1900 then, the population was 7.13 times the school enrollment, and in 1910 it was 8.31 times the school enrollment. Factors for intermediate years have been estimated by interpolation and used to multiply the known school enrollment for the intermediate years in order to give the estimated population. Similar methods were used for estimates from the city directory and from the registered voters. The figures will not be given here, but the results of all such estimates are shown in the following diagrams:

No. 12 for San Francisco.
No. 13 for Alameda.
No. 14 for Richmond.
No. 15 for Oakland, Berkeley and vicinity.
No. 16 for Greater San Francisco.
No. 17 for the San Francisco Bay counties.

Many of the curves show very erratic tendencies. There is a very marked disturbance in the population of the San Francisco Bay cities for the years 1906 and 1907, due to the earthquake and fire, which partially destroyed San Francisco. The most probable population for intermediate years between census years was taken as the actual mean or average of all the plotted curves.

Forecast for Future Population.

The mean curves on diagrams Nos. 13 to 18 have been extended so as to give a forecast of future population up to the year 1920. The abnormal years of 1906 and 1907 were not considered, but the average percentage yearly rate of increase for all other years except these two, as shown on the mean curve up to 1910, was computed for the years 1900 to 1910, and it was assumed that the rate of growth for the next ten years would be the same. The curve for San Francisco, for example, from 1910 to 1920 has been plotted with a constant yearly increase of 4 per cent, and the population of all the other bay cities, with the exception of Richmond, was treated in a similar manner.

Richmond.

As the records for Richmond are available for such a brief period, an effort was made to secure greater accuracy by assigning different weights to the yearly rate of increase. The ratio between school census and total population is assumed constant for the years 1903 to 1910, as it is impossible to determine how it varied. The population for each of the years 1903 to 1910 was obtained from the other sets of statistics with the same assumption.

DIAGRAM No 13
SAN FRANCISCO BAY HARBOR STUDIES
ESTIMATED
PROBABLE FUTURE POPULATION
CURVE
giving
SAN FRANCISCO
METHOD No 2 — CITIES OWN PAST GROWTH

Sept 1912

Haviland & Tibbetts
Civil Engineers
San Francisco.

Note.— the curve showing the estimated
population presents an average of the
computed population curves plotted from
the School enrollment, City directory
and registered voters.

The curve showing the probable
future population is based on a con-
stant yearly increase of 43%. This per-
centage is an average of the average rate of
growth shown by the curve of estimated
population over the past years—the years
1906—1908 being excluded.

ESTIMATED POPULATION
LEGEND
Population based on School Census
"   "   " School Enrollment
"   "   " City Directory
"   "   " Registered Voters
Mean Estimated Population

Scale of Population

Scale of Years

DIAGRAM Nº14.

SAN FRANCISCO BAY HARBOR STUDIES

CURVE
SHOWING

ESTIMATED
AND
PROBABLE FUTURE POPULATION
OF
CITY OF ALAMEDA

METHOD Nº 2—CITIES OWN PAST GROWTH

SEPT 1912   1920

Haviland & Tibbetts Eng'r.
Civil & Consulting Eng'r.
San Francisco.

Scale of Years

Mean curve represents a mean of the curves showing population estimated from school census, school enrollment, registered voters, and city directory.

Curve showing Future Population is projected on the mean rate of increase as shown by mean curve from 1900 to 1906 and from 1907 to 1910.

LEGEND:—
———+———+——— School Enrollment Population
———+———+——— School Census Population
———+———+——— Registered Voters Population
———+———+——— City Directory Population
——————————— Estimated Mean Population
— — — — — — Probable Future Population

The Population on the several bases for the ten years between 1900 and 1910 was derived by computing the ratio of each year to that of the year before for the 1900 and 1910 to the actual population arrived at by using the mean and projected curves by making the 2nd difference of ratios in consecutive years equal.

Population

DIAGRAM N.º 15

SAN FRANCISCO BAY HARBOR STUDIES

CURVES

ESTIMATED

PROBABLE FUTURE POPULATION

OF

CITY OF RICHMOND

METHOD N.º 2—CITIES OWN PAST GROWTH

Note:—
The curve showing estimated popul-
ation previous to 1910 is a mean of the
population curves plotted from com-
puted populations based on school en-
rollment, school census, and registered
voters.

The curves showing probable future
population are plotted with a constant
percentage of yearly increase. 6.8%
is the average of the percentages of
yearly growth from 1900 to 1910 as
shown by the estimated mean. The
6.8% curve shows a probable mar-
imum growth.

7.3% is the average of the percent-
ages of yearly growth from 1900 to 1910
exclusive of 1906-07, in which there is
occured an abnormal growth. This
projected curve will show a probable
mean growth.

4% is the lowest percentage of yearly
growth shown during the past decade.
The 4% curve will show a probable
minimum.

ESTIMATED POPULATION LEGEND
——— Population based on School Enrollment
— — —   "   "   Census
· · · · · ·   "   Registered Voters
——— Mean Estimated Population.

DIAGRAM Nº 16
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
ESTIMATED
AND
PROBABLE FUTURE POPULATION
OF
OAKLAND BERKELEY
AND VICINITY
INCLUDING
ALBANY PIEDMONT & EMERYVILLE
METHOD Nº 2—CITIES OWN PAST GROWTH
SEPT. 1912
Haviland & Tibbetts
Civil & Consulting Engrs.
San Francisco

Scale of Years

Note:
DIAGRAM N⁰ 14
The maximum, mean, and minimum curves for the Combined Bay Counties are constant percentage curves plotted at of 40%, 30%, and 20% increase per decade. These percentages are the maximum, mean and minimum rates of growth of the combined Bay Counties from 1890 to 1910.
The probable future population is shown by a straight line which is an average of of the 30% curve

Bay Counties— Alameda, ContraCosta, Marin, Napa, SanFrancisco, SanMateo, Santa Clara, Solano, and Sonoma

DIAGRAM N⁰ 13
The maximum, mean, and minimum curves for Greater San Francisco are constant percentage curves plotted at 47%, 34%, and 23% increase per decade. These percentages are the maximum, mean and minimum rates of growth of Greater San Francisco from 1890 to 1910
The probable future population is shown by a straight line which is an average of the 34% curve
Greater San Francisco— San Francisco Oakland Berkeley & vicinity, Alameda Richmond, San Leandro, Colma, and South San Francisco

DIAGRAMS N⁰ 17 & 18
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE POPULATION
GREATER SAN FRANCISCO
AND
COMBINED BAY COUNTIES—
METHOD N⁰2 ~ CITIES & COUNTIES OWN PAST GROWTH
SEPT 1912
Havilland & Tibbetts
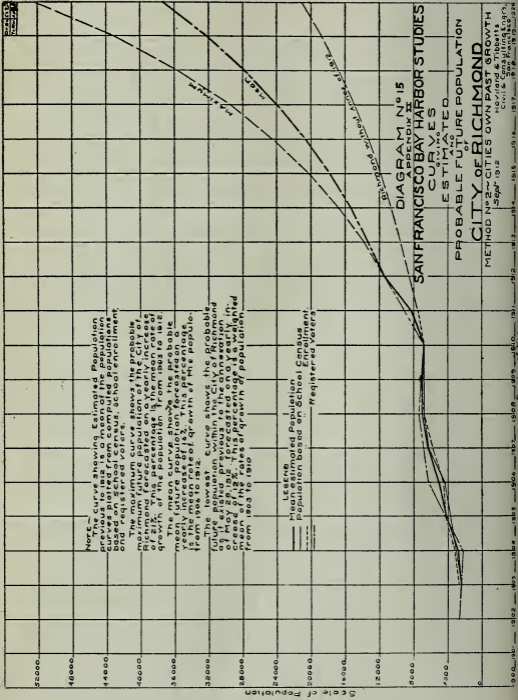Civil & Consulting Engrs.
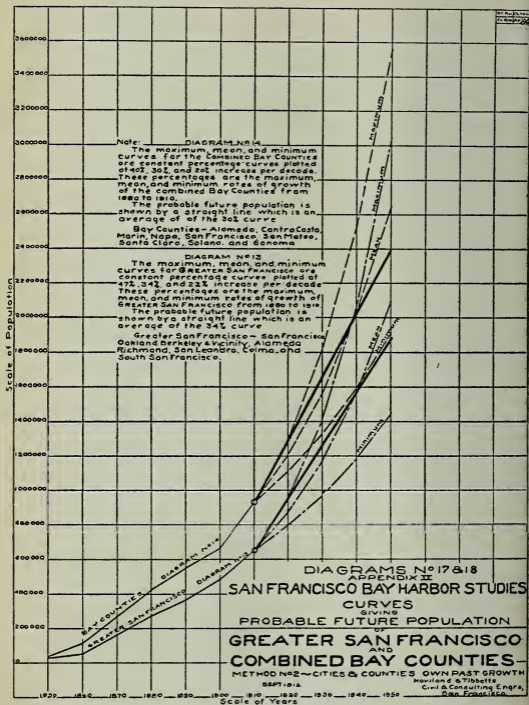San Francisco

Scale of Population

Scale of Years

Table No. 41—Population of Richmond, Estimated From School Census, School Enrollment and Registered Voters.

Year	School Census	Factor	Pop.	School Enrollment	Factor	Pop.	Registered Voters	Factor	Pop.
1902	......	....	....	...	...	....	658	4.1	2,700
1903	.. 456	5.24	2,400	277	7.48	2,700	570	4.1	2,340
1904	....	....	....	425	7.48	3,180	.....	...	.....
1905	....	....	....	575	7.48	4,300	.....	...	.....
1906	.. 847	5.24	4,400	605	7.48	4,250	1,538	4.1	6,300
1907	.. 1,201	5.24	6,300	775	7.48	5,800	.....	...	.....
1908	.. 1,295	5.24	6,890	916	7.48	6,860	1,811	4.1	7,430
1909	.. 1,299	5.24	6,820	963	7.48	7,200	.....	...	.....
1910	.. 1,296	5.24	6,802	910	7.48	6,802	1,565	4.1	6,802
1911	.. ..	....	.....	....	7.48	.....	.....	...	.....
1912	.. ..	....	....	(Including Annex)			2,800	4.1	11,480

The mean curves obtained from each set of statistics in the above table, as well as the mean of all three were then plotted. This mean shows that the population of Richmond increased uniformly to 1908, very slightly to 1910, and very rapidly to 1912. The percentage of future increase was obtained by taking the mean yearly percentage growth from 1906 to 1912. It was thought that greater weight should be given to the recent years because the causes affecting the growth of Richmond could have crystallized only very recently. The results of these computations are shown in Table No. 42, as well as Diagram No. 15.

Table No. 42—Weighted Mean Estimated Population of Richmond

Year	Population	Difference	Per Cent	Year	Population
1903	2,300	.....	....	....	......
1904	2,900	600	25	....	......
1905	4,200	1,300	45	1913	13,300
1906	5,100	900	21	1914	15,300
1907	6,300	1,200	24	1915	17,600
1908	7,000	1,700	14	1916	20,800
1909	7,060	60	1	1917	24,000
1910	6,802	258	—3	1918	27,800
1911	8,400	1,598	23.5	1919	32,200
1912	11,480	3,080	36.7	1920	37,400

It is seen in the above table that the yearly percentage of increase varies from minus 3, to 45. The actual average of these rates of growth was 21 per cent, but the mean average, used by attaching greater importance to the lesser rates of growth in recent years, was 16 per cent. This latter rate of 16 per cent was as-

sumed to apply in forecasting the future population up to 1920. These results, of course, are inclusive of the recent annex.

Summary—Population Forecasts.

In general it will be found that the estimated population for San Francisco shows a rather uniform rate of growth up to 1906, and a resumption in 1908 of the former rate of growth. The cities on the east shore of the bay show a rather uniform rate of growth up to 1906, then a sudden increase, due to the San Francisco fire, followed by a return in 1908 to the normal rate. For the years 1908 to 1910 the cities of Alameda and Richmond show a very low rate of growth, and even a slight decrease. In the forecasting for the next decade, however, the population of all bay cities and counties is assumed to increase at the average yearly rate for the last decade, excluding the abnormal years. Richmond, as previously noted, is an exception, the average yearly previous rate of increase being modified as shown in Table No. 42. A final summary of population forecasts is shown in Table No. 43, using "Method No. 2" up to 1920 and "Method No. 1" for 1930, 1940 and 1950.

Table No. 43—Summary of Population Forecasts, San Francisco Bay Region.

Year	San Francisco	Oakland, Berkeley and Vicinity	Alameda	Richmond (Inclusive of Recent Annex).	Greater San Francisco.	Bay Counties.
1910......	416,912	195,748	23,383	6,802	651,805	925,708
1920......	632,000	392,000	30,000	37,400	959,000	1,300,000
1920......	610,000	311,000	43,000	20,000	998,000	1,280,000
1930......	810,000	428,000	61,000	45,000	1,388,000	1,720,000
1940......	1,290,000	558,000	105,000	62,500	2,074,000	2,410,000
1950......	1,610,000	711,000	144,000	103,000	2,630,000	3,000,000

FORECAST OF FUTURE WEALTH OF SAN FRANCISCO BAY CITIES.

Sources of Information.

No statistics are available which give a complete valuation of a community's wealth. The best index of the total wealth is the assessed valuation made for tax levies. This is used not only as an

index to the community wealth, but also as a basis from which to compute public revenues. It is difficult to make comparisons with other cities, because the methods used in various cities in fixing the assessed valuation vary so widely, and because the classes of property included in the available data are not always known. There is also a great variation in the ratio of assessed to actual valuation in various cities. In California the state law requires that property shall be assessed at its full value, but in practice this is never done. The assessed valuation is usually about 60 per cent of the market valuation, but in some cities and counties may be much less. In other American cities it may be equal to the market valuation.

The assessed valuation of the Bay Counties was obtained for each ten years from 1870 to 1910 from reports of the State Controller. These valuations include real estate, personal property, money, solvent credits, and, prior to 1874, railroad property.

The assessed valuations of the bay cities were obtained for each year since 1880 from City and County Auditors' reports, and include the same classes of property as the county assessments.

The assessed valuation of railroad property in the bay cities and counties was obtained from the State Controllers' reports and County Auditors' reports from 1894 to 1910. Prior to 1894, railroads were assessed by the County Assessors and not segregated. The county and city assessed valuations for 1911 do not include operative property of certain semi-public corporations.

The assessed valuations of American cities was compiled from the United States census reports for 1890 and the World's Almanac and Encyclopedia for 1890 and 1910. Nothing is given to determine what classes of property these figures include. Per capita valuation is included.

Bank deposits are also an index of a community's wealth. They are included, however, in a complete assessed valuation. Bank deposits do not vary in a reverse direction within a short term of years as often as assessed valuations do, and therefore may have advantages as an index of wealth. Only assessed valuations were compiled and used in the study of wealth given in this appendix.

Table No. 44—Assessed Valuations and Wealth Per Capita of Principal American Cities for Census Years.

Cities	ASSESSED VALUATION				WEALTH PER CAPITA			
	1880	1890	1900	1910	1880	1890	1900	1910
Albany	$ 33,746,992	$ 62,556,881	$ 66,841,295	$ 82,438,325	$ 372	$ 659	$ 710	$ 823
Atlanta	18,000,000	41,405,150	52,000,000	101,000,000	481	632	578	547
Baltimore	244,043,181	278,249,691	365,847,456	624,482,590	734	640	718	1,107
Birmingham	698,164	17,000,000	.....	.....	226	649	.....	2,010
Boston	639,462,495	822,041,800	1,089,808,120	1,348,041,627	1,762	1,832	1,915	.....
Brooklyn	232,925,699	445,038,201	655,092,980	1,439,142,030	411	552	.....	.....
Buffalo	83,910,583	160,266,391	236,969,535	307,300,555	541	627	672	726
Cambridge	48,968,900	67,471,925	90,000,000	106,958,135	930	963	980	1,020
Charleston	22,543,423	18,805,502	17,361,411	18,860,821	451	343	312	323
Chicago	117,970,035	219,356,280	220,966,447	477,190,399	234	199	130	218
Cincinnati	169,305,635	177,773,240	199,739,080	250,283,550	664	599	612	688
Cleveland	70,548,104	99,614,055	142,290,775	256,719,375	441	381	373	458
Columbus	27,439,382	43,663,270	64,344,990	87,307,905	513	495	512	481
Denver	16,194,091	66,624,750	61,443,210	132,000,000	454	624	459	619
Detroit	83,198,040	143,993,438	216,971,090	359,519,910	715	699	760	773
Duluth	529,730	23,766,633	26,865,943	37,283,400	632	718	508	475
Elizabeth	11,540,835	14,504,618	17,492,021	52,065,175	409	330	330	710
Elmira	10,797,029	14,864,487	17,283,361	20,215,776	526	481	485	544
Galveston	14,904,856	19,554,010	.....	25,734,412	670	672	.....	696
Indianapolis	48,099,940	58,205,890	119,856,680	176,665,190	641	552	710	757
Jersey City	58,411,959	76,121,955	91,850,000	235,617,539	484	467	445	880
Kansas City	10,577,260	82,485,557	70,000,000	135,580,492	190	622	427	546
Louisville	65,809,000	88,812,574	119,500,000	165,000,000	532	551	584	738

Table No. 44 (Continued)—Assessed Valuations and Wealth Per Capita of Principal American Cities for Census Years.

Cities	ASSESSED VALUATION				WEALTH PER CAPITA			
	1880	1890	1900	1910	1880	1890	1900	1910
Milwaukee	55,875,969	105,484,055	151,791,903	232,227,790	483	516	532	621
Minneapolis	23,415,733	137,102,176	108,000,000	175,912,389	499	832	793	584
Newark	83,364,410	112,512,530	144,355,011	327,926,050	611	619	587	942
New York	1,094,069,335	1,618,740,805	3,478,352,029	7,250,500,550	907	1,068	1,012	1,522
Omaha	7,512,683	19,989,715	34,907,399	27,571,271	246	142	340	222
Paterson	19,893,485	28,824,280	....	95,243,359	390	368	...	758
Philadelphia	581,729,759	974,338,294	1,238,586,991	1,358,675,057	687	931	958	877
Pittsburg	81,238,998	157,959,041	361,000,000	709,905,718	520	662	1,123	1,330
Portland	13,143,425	25,660,965	38,396,620	240,000,000	748	553	435	1,160
St. Louis	165,288,400	247,242,965	373,561,953	533,456,571	472	547	650	776
St. Paul	24,000,000	121,439,930	95,000,000	104,755,800	579	912	582	488
Salt Lake City	7,304,325	48,000,000	....	52,194,220	352	1,070	....	563
Seattle	1,626,275	26,314,045	32,863,292	185,317,470	460	615	400	782
South Bend	4,809,005	6,224,410	....	....	362	285	...	...
Tacoma	280,000	29,750,346	22,549,840	63,925,693	255	826	598	644
Washington	....	134,115,621	190,958,897	312,473,714	...	710	686	944

U. S. Census Reports, wealth, debt and taxation, 1890. World's Almanac and Encyclopedia, 1900 and 1910. (See Table No. 45 for San Francisco Bay region.)

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Table No. 45—Assessed Valuation of San Francisco Bay Cities.

Year	*San Francisco	Oakland	Berkeley	Alameda	Emeryville	Richmond	Piedmont	Albany
1850	$ 21,621,184	$........	$........	$........	$........	$........	$........	$........
1860	35,967,499							
1870	105,025,534							
1871	106,391,876							
1872	288,533,256							
1873	212,407,505							
1874	264,229,444							
1875	269,105,141							
1876	260,576,987							
1877	254,867,050							
1878	244,477,360		2,263,114	3,127,735				
1879	217,487,074			3,765,075				
1880	253,520,326	28,691,610		4,743,930				
1881	239,423,662	28,238,631		4,761,653				
1882	202,162,007	28,289,650	1,667,287	4,843,800				
1883	253,452,389	28,353,338	2,162,889	5,114,012				
1884	245,157,396	28,794,949	2,454,514	5,771,042				
1885	254,325,953	29,217,050	2,520,047	6,251,273				
1886	230,151,009	29,866,200	2,627,226	6,489,438				
1887	25,174,611	32,096,250	2,792,745	6,677,458				
1888	273,380,616	33,802,450	3,292,481	7,354,298				
1889	290,380,616	33,802,450	3,292,481	8,101,078				
1890	301,444,140	39,453,392	3,925,272	9,225,265				
1891	399,826,077	42,729,380	4,518,655	10,459,919				
1892	412,047,076	44,481,250	6,674,888	11,611,274				
1893	342,644,174	44,821,250	7,414,557	12,019,785				
1894	325,108,898	45,382,350	8,283,065	12,511,629				

Table No. 45 (Continued)—Assessed Valuation of San Francisco Bay Cities.

Year	*San Francisco	Oakland	Berkeley	Alameda	Emeryville	Richmond	Piedmont	Albany
1895	327,805,147	46,146,798	8,006,430	12,665,774	....	....	....	....
1896	422,069,716	45,550,970	8,270,506	11,972,079	....	....	....	....
1897	347,954,920	48,646,981	8,444,930	12,650,882	714,200	....	....	....
1898	352,344,061	42,391,955	8,418,720	12,539,987	663,650	....	....	....
1899	405,111,615	43,275,381	8,593,005	11,265,677	693,436	....	....	....
1900	410,155,304	44,224,168	8,948,710	11,381,997	748,491	....	....	....
1901	413,099,993	44,746,716	9,576,940	11,619,872	750,188	....	....	....
1902	419,988,644	45,209,597	10,596,028	11,574,532	770,902	....	....	....
1903	545,866,446	51,151,702	12,230,695	12,214,318	1,204,617	....	....	....
1904	502,892,459	51,656,242	14,012,765	12,527,012	1,211,577	....	....	....
1905	524,230,946	55,347,543	16,420,016	12,876,782	1,301,545	....	....	....
1906	375,932,447	61,148,804	23,765,489	13,739,755	1,532,420	3,417,270	....	....
1907	429,632,593	100,434,412	27,963,827	15,634,709	2,652,820	5,157,526	2,785,800	....
1908	454,334,160	103,653,400	31,597,998	17,034,179	2,838,645	6,862,225	3,082,950	....
1909	492,867,037	107,793,550	33,899,444	17,953,866	3,077,243	7,610,161	3,633,165	....
1910	515,028,064	‡117,844,224	35,736,140	18,848,089	3,733,776	7,888,147	3,506,101	1,093,744
1911	461,855,781	‡109,124,037	37,102,245	19,393,490	2,650,700	8,896,225	3,553,225	1,099,458
1912	....	....	....	....	....	12,357,779	....	1,078,750

Old City of Richmond in 1912, $10,110,424.
City Auditors' reports.
*Report of Commission on Revenue and Taxation, 1906.
†Includes $1,231,890 operative property.

Richmond Annex of 1912, $2,254,325.
‡County Auditors' reports.
Figures do not include railroad property assessed by the State.

Methods of Forecasting Future Valuations.

The second general method used in forecasting population by comparing with the previous rate of growth may also be used for forecasting future valuations. The first method, however, based upon the rate of growth of other cities is not very satisfactory, because available data does not usually extend far enough back to give a reliable comparison. In the present study of population for Oakland, Berkeley and vicinity, for example, eight other cities were used, but data could be obtained for only three of these for the study of assessed valuation. Method No. 2, based upon past rates of growth of the same community, was used exclusively for all forecasts of future valuations.

Forecasts of Future Valuations.

Table No. 44 shows the assessed valuation and wealth per capita of the principal American cities for the census years 1880 to 1910, Table No. 45 shows the assessed valuation of the San Francisco Bay cities from 1850 to 1911 and Table No. 46 shows the assessed valuation of the San Francisco Bay counties for the census years 1850-1910.

Table No. 46—Assessed Valuation of San Francisco Bay Counties for Census Years.

Counties	1870	1880	1890	1900	1910
Alameda	$ 11,786,381	$ 49,286,463	$ 76,269,176	$ 86,922,760	$200,206,102
Contra Costa .	2,802,657	8,175,682	15,552,354	16,504,307	35,399,378
Marin	3,588,449	8,924,530	11,416,412	11,994,714	19,709,273
Napa	3,942,966	9,182,661	14,887,827	11,633,300	16,688,224
San Francisco.	116,375,988	253,520,326	301,559,510	410,425,849	515,420,089
San Mateo ...	1,901,955	7,764,610	13,884,376	14,421,010	27,573,681
Santa Clara .	11,813,882	25,514,842	52,284,812	51,971,268	73,144,102
Solano	6,945,725	12,130,018	19,350,253	17,519,315	22,822,851
Sonoma	6,920,006	18,809,793	30,262,540	25,753,672	36,822,794

State Controller's report.
Annual report of California Development Board, 1911.

From the above tables have been plotted diagrams showing graphically the increase in wealth of the San Francisco Bay cities, as follows:

Diagram No. 19,   San Francisco.

Diagram No. 20, Alameda.

Diagram No.21,Richmond.

Diagram No. 22, Oakland, Berkeley and vicinity.   (Includes Alameda.)

Diagram No. 23, Greater San Francisco.

Diagram No. 24, Combined San Francisco Bay counties.

Compared with population curves, assessed valuation curves show much greater and more erratic fluctuations. This is due partly

to plotting annual, instead of decennial values, a method which tends to catch the temporary changes in the community, but principally to changes in the methods and personal equations of successive assessors. The former cause of variation is shown to be eliminated by the ten-year values plotted in the curve for the combined bay counties, although the smoothness of this curve is also due partly to the automatic balancing of local changes by combination.

Wide differences in the valuation of the cities in the range of years plotted, made necessary variations in the scales on different sheets so that the relative rates of growth can not be inferred from the slope of the curves.

Five methods were used in forecasting the probable future valuations, as follows:

1st, a straight line projection of the average growth for the last decade.

2nd, a straight line projection of the same average on logarithmic paper, transferred to natural scale paper.

3rd, a curve plotted from figures, computed by using the average annual or decennial percentage rate of increase for a certain period in the past.

4th, a curve plotted from figures computed by assuming a constant wealth per capita for the future population as estimated in the population forecasts.

5th, a curve plotted from figures computed by using the average annual percentage rate of increase in the wealth per capita in the past, in connection with the future population as estimated.

Three of these methods are used for each city studied, and the curves constructed which give the maximum, mean and minimum of all five, the methods being chosen so as to give three variations. The method of computing each curve is described on the diagrams.

The San Francisco curve shows a very erratic growth, rising and falling, seemingly on account of variations in methods of assessment and amount of desired revenue. A prediction for the future from such a curve is exceedingly difficult. A study of this curve was published in the Report of the Commission on Revenue and Taxation for 1906. It showed a long term average, but no forecast was attempted. In the forecast on Diagram No. 19 the years 1900-1910, exclusive of the year 1906-1907, were considered to give the most reliable basis; 1st, because they show less variations in reverse directions; 2nd, because the recent years should be the index of the accelerated growth of San Francisco, and, 3rd, because there was a more settled policy in making up assessments in recent years.
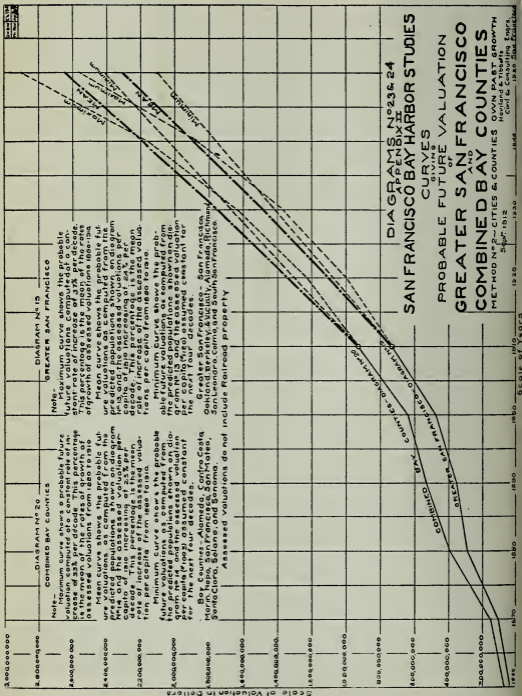
Note. The maximum curve gives the probable maximum future assessed valuation of San Francisco as computed from the assessed valuations of 1910 and previous years. The percentage is the mean rate of growth of assessed valuation from 1900 to 1910, which is the highest of the rates compared. The minimum curve gives the probable minimum future assessed valuation computed from the predicted population (Motograph) by increasing at 1.3% yearly. This percentage is the ratio of the increase of assessed value per capita from 1900 to 1910 (including 1904 and 1910).

The minimum curve gives the probable minimum future assessed valuation computed from the predicted populations (Motograph) and assumed values per capita remaining constant. The predicted values assumed to remain constant for the next 30 years, is computed at maximum future assessed valuation of Steve and County taxes by.corporations from county tax often assessed per capita. The predicted assessed valuation is for County taxation only

DIAGRAM N°19
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE
ASSESSED VALUATION OF
SAN FRANCISCO
METHOD OF CALCULATING FUTURE GROWTH
WAS—CITIES OWN PAST.
1913

Haviland & Tibbetts
Civil & Consulting Engrs.
San Francisco

DIAGRAM No. 2
APPENDIX II

SAN FRANCISCO BAY HARBOR STUDIES
CURVES

GIVING
PROBABLE FUTURE
ASSESSED VALUATION

CITY OF ALAMEDA
METHOD No. 2 — CITIES OWN PAST GROWTH

SEPT. 1912

Havilland & Tibbitts
Civil & Consulting Engrs.
San Francisco.

Note:— The maximum curve gives the probable maximum future assessed valuation of Alameda City as computed from the predicted population shown on diagram one with the assessed valuation per capita for 1910, and year of increase of each. This percentage is the mean yearly rate of growth of the assessed value for 20 years from the assessor's roll.

The mean curve is a straight line projection for 1910 and 1912. This curve gives the mean future assessed valuation.

The minimum curve gives assessed valuations computed from predicted population with the assessed valuation per capita in 1910 assumed constant for the next decade.

The assessed valuations are taken from the City assessor's rolls.

Scale of Years

Scale of Valuation in Dollars

Note:—
The probable maximum future valuation of the city of Richmond is forecasted from 1912 with a constant valuation percapita (1912) of the populations shown in diagram N°. 11

The probable minimum future valuations are forecasted on a constant percentage (012) of yearly increase. This percentage is the mean of the rates of growth of the assessed valuations from 1900 to 1912, using the assessed valuations of the old city of Richmond in 1912.

The probable mean future valuation curve is an actual mean of the maximum and minimum curves.

DIAGRAM N°.21.
APPENDIX II
SAN FRANCISCO BAY HARBOR STUDIES
CURVES
GIVING
PROBABLE FUTURE VALUATION
OF
CITY OF RICHMOND
METHOD N°2.— CITIES OWN PAST GROWTH
Sept. 1913   Haviland & Tibbetts
                   Civil & Consulting Engrs
                   San Francisco.

Scale of Years

NOTE—Oakland, Berkeley and vicinity includes Alameda.

DIAGRAMS Nos 23 & 24

SAN FRANCISCO BAY HARBOR STUDIES

CURVES SHOWING
PROBABLE FUTURE VALUATION
OF
GREATER SAN FRANCISCO
AND
COMBINED BAY COUNTIES
METHOD No 2 — CITIES & COUNTIES OWN PAST GROWTH

Newland & Stewart
Carl E. Grunsky
1920 San Francisco

DIAGRAM No 20
COMBINED BAY COUNTIES

Note.— Maximum curve shows the probable future valuation computed at a constant rate of increase per capita. This is the average rate of increase of the past decades.

Mean curve shows the probable future valuation computed from a predicted population, increasing per capita of the assessed valuation at the rate of one increasing at 2.5% per annum rate of increase of the assessed valuation per capita.

Minimum curve shows the probable future valuation as computed from a predicted population, increasing per capita at a constant of the assessed valuation for the next four decades.

The Bay Counties are Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma.

Assessed Valuations do not include Railroad property.

DIAGRAM No 19
GREATER SAN FRANCISCO

Note.— Maximum curve shows the probable future valuation computed at a constant rate of increase per capita. This percentage is the mean of the rates of increase of valuation per capita.

Mean curve shows the probable future valuation as computed from the predicted population, increasing per capita at the rate of one increasing at 2.5% per annum, rate of increase of the assessed valuation per capita.

Minimum curve shows the probable future valuation as computed from a predicted population, increasing per capita and the assessed valuation per capita assumed constant for the next four decades.

Greater San Francisco = San Francisco, Oakland, Berkeley, Alameda, Richmond and the suburban cities bordering San Francisco Bay. Does not include Railroad property.

Scale of Valuation in Dollars

3,000,000,000
2,800,000,000
2,600,000,000
2,400,000,000
2,200,000,000
2,000,000,000
1,800,000,000
1,600,000,000
1,400,000,000
1,200,000,000
1,000,000,000
900,000,000
800,000,000
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000

1870 1880 1890 1900 1910 1920 1930 1940

Scale of Years

COMBINED BAY
GREATER SAN FRANCISCO

COUNTIES-MISSISSIPPI
COUNTIES-FRANKLIN

The curve for Oakland, Berkeley and vicinity (including Alameda) shows a rather uniform rate of increase if we except the year 1906, which was the result of the catastrophe in San Francisco. The inclusion of this year gives two curves for the future, which are much higher than a third curve excluding it. The minimum curve on this sheet is probably the most rational.

The City of Alameda exhibits three periods with different rates of growth: 1st, 1880 to 1894, a uniformly rapid rate; 2nd, 1894 to 1902, a stationary condition; 3rd, 1902 to 1911, a uniformly rapid rate similar to the period 1880 to 1894. The period 1900 to 1910 was taken as the best basis for a forecast to 1920.

The study of Richmond includes the city as incorporated after the annexation of Pullman, Stege and surrounding areas in May, 1912. Figures for the annexed district previous to 1912 are not obtainable. The curve of past growth is fairly uniform, with a lessened rate in the period 1908 to 1910, and a very rapid rate since 1910. The maximum and minimum curves diverge widely. For 1920 the maximum figure is $40,000,000; the minimum, $26,500,000; the mean $33,200,000

The combined bay counties exhibit a more uniform rate of growth than any of the bay cities. The curve would show more variations if data for each year were plotted. The maximum, minimum and mean curve of probable future valuation lie close together and the mean curve averages the maximum and minimum rather well.

Summary of Valuation Forecasts.

The following Table No. 47 gives a final summary of assessed valuations as deduced from the studies given above.

Table No. 47—Summary of Assessed Valuation Forecasts for San Francisco Bay Cities and Counties.

Cities	1910	1920	1930	1940	1950
San Francisco	515,028,064	754,000,000	....	....	....
*Oakland	180,700,000	318,000,000	....	....	....
Alameda .	18,848,089	25,900,000	....	....	....
Richmond .	7,888,147	33,270,000	....	....	....
Greater San Francisco.	730,000,000	1,101,000,000	1,486,000,000	1,890,000,000	2,312,000,000
Bay Counties	928,700,000	1,340,000,000	1,750,000,000	2,190,000,000	2,650,000,000

*Oakland includes Alameda, Berkeley and vicinity.
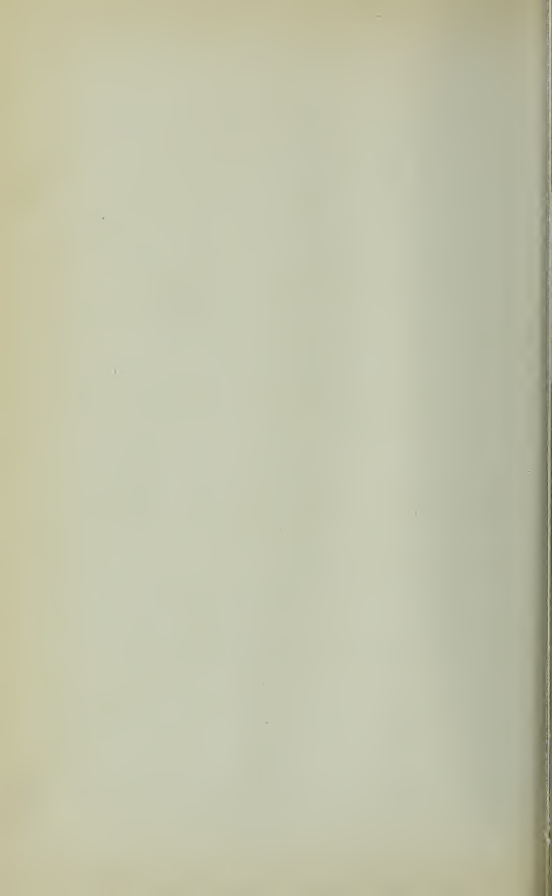
Appendix No. III

Dimensions of Shipping Used in San
Francisco Bay

DIMENSIONS OF SHIPPING USED IN SAN FRANCISCO BAY

Scope of Investigation.

One of the first steps in the design of harbor improvements is a determination of the dimensions of the vessels which are to be accommodated. This affects the depths of channels or slips, the widths and lengths of wharves or piers, and the total amount of commerce to be provided for.

The principal factors of importance are the main dimensions of the vessels, such as breadth of beam, length, free-board and maximum loaded draught. In order to make the most rational study of the economical development of any port, it is also desirable to know the relative amounts of commerce handled by vessels of different sizes. There is no mathematical relation that is at all constant between the various dimensions of a ship. The designer of a new ship is generally required to design her for a certain trade, cargo or passenger-carrying capacity and speed. Ships intended for different trades vary greatly in strength, in dimensions and lines of hull and in speed. The dimensions are determined largely from experience and empirical data, but the lines of the hull and power equipment are worked out by rational and empirical formulae, based mostly on the speed required. For these reasons and the constant advance in the marine architects' knowledge of his art, dimensions of vessels can be determined only from tabulated data.

Ship Measurements.

Navigation laws usually require a ship to be measured by an official marine surveyor when she applies for registry. Vessels under a certain size are exempt from this rule. American vessels are catalogued in a publication issued yearly by the United States Commissioner of Navigation. British vessels and many other foreign vessels are catalogued in Lloyds' Register of Shipping, issued by a committee with head office in London. The other leading maritime nations also have official registers of vessels.

The measurements of a ship and the method of making them by a marine surveyor is prescribed by the navigation law. In this country, those laws are administered by the Commissioner of Navi-

gation and the Steamboat Inspection Service of the Department of Commerce and Labor. The British navigation laws are administered by the British Board of Trade.

The **gross tonnage** of a ship is the total internal cubical volume, in tons of 100 cubic feet. An approximate rule for determining this is: Gross tonnage under deck, equals length, times breadth, times coefficient of displacement, divided by one hundred. To the result thus obtained is added the enclosures above the deck, in the sums of their capacity in cubic feet divided by one hundred. If there is a double bottom, the space beneath the false bottom is not included. The divisor of one hundred is arbitrarily chosen and fixed by law because of its convenience, and because of the fact that generally it gives results close to those obtained by determining tonnage according to dead weight of cargo.

The coefficient of displacement is the ratio between the volume enclosed by the outer surface of a vessel's hull and the volume of the circumscribed, rectangular parallelopipedon, whose dimensions are length, times breadth, times depth to water line. In the above formula the coefficient of displacement has the following approximate values:

Passenger steamers of high speed and sailing ships .6 to .65.

Passenger and cargo steamers, .7 to .72.

Cargo steamers and oil tank steamers, .72 to .8.

The **net registered tonnage** is demoined by deducting in general all spaces not usable for cargo and various other spaces fixed by law. The ratio of the dead weight carrying capacity to the net registered tonnage varies from one and one-half to one and one-fourth in steel sailing vessels. It is about one and three-fourth in cargo steamers. For passenger steamers it varies greatly and sometimes is less than unity.

To determine **dead weight carrying capacity**, a freight ton is taken as being forty cubic feet of space available for cargo, and is two-fifths of a registered ton, which is 100 cubic feet of space.

The **draught** of a ship at any given time is the maximum vertical distance between the water surface and the lowest portion of the vessel. This, of course, varies with the loading and is not a fixed quantity. Great variations are also caused by variations in weight of hull, cargo-carrying capacity and displacement coefficient. A vessel when loaded usually does not have a level keel, but draws a greater depth of water aft than forward.

The **free board** of a ship is the height of the upper deck, amidships above the water line. It varies greatly, depending upon her

use and strength of build. The draught of steamers listed in Lloyds' Register of Shipping can be closely determined by subtracting the free board from the molded depth.

The **molded depth** is the depth from the top of the upper deck beam, amidships, to the top of the keel.

The **registered depth** differs from the molded depth, and generally is the depth inside the hull, except for ships having a double bottom, where it is the distance from the false bottom to the main deck.

Lloyd's committee tabulated data on loading of vessels and issued this in 1882, and the British Board of Trade adopted this data as their basis upon which load lines fixing the free board of vessels should be determined. There is no such central body as the British Board of Trade with authority to assign free boards to vessels registered in the United States. Many American vessels plying in and out of the port of San Francisco reduce their free boards when loaded to two feet less than the free board assigned by their designers. Lumber vessels in particular pay very little attention to assigned free boards and often are loaded until the decks are almost awash.

Construction of Diagrams.

Table No. 48 (Appendix No. III) gives the dimensions of some of the best known steamers, including many making regular trips to the port of San Francisco.

Table No. 49 (Appendix No. III) gives a classification of ocean traffic arriving at the San Francisco wharves during the fiscal year 1909 to 1910, showing the percentage of the total tonnage carried by ships of different sizes. From these two tables were plotted diagrams Nos. 25 and 26 (Appendix No. III).

Diagram No. 25 gives five curves showing the relation between the four principal ship dimensions, of breadth, length, loaded draught and net tonnage. It is not practicable to show the relation between more than two dimensions of a ship in one curve. The four principal curves give directly the relation between the following quantities: 1st, length and breadth: 2nd, length and loaded draught: 3rd, length and net registered ship tonnage: 4th, loaded draught and net registered ship tonnage. As the plotted points are badly scattered it was thought best to draw a maximum and minimum curve for each case, enclosing the total area of the plotted points, as well as the mean. As the river boats are necessarily of very shallow draught, a separate curve has been plotted showing the relation between their length and draught.

CURVES
GIVING
DIMENSIONS
OF
SHIPS

SAN FRANCISCO HARBOR STUDIES
APPENDIX III
DIAGRAM Nº 25
Sept.1913   Haviland & Tibbetts, Civil Engineers
San Francisco

CURVES
GIVING
LIMITING DIMENSIONS
AND
TONNAGE OF VESSELS
CARRYING CERTAIN PERCENTAGES
OF NET REGISTERED OCEAN TONNAGE
DOCKED AT STATE WHARVES

SAN FRANCISCO
HARBOR STUDIES
APPENDIX III
DIAGRAM No. 24

NOTE
To illustrate the method of using the curves. The curve of draft reads thus: 50% of the net registered ocean going tonnage docked at the State wharves of San Francisco in the year ending June 30 1910 was carried by vessels of 21 ft or less loaded draft

LOGARITHMIC SCALE CROSS-SECTION
6 INCH BASE
EUGENE DIETZGEN CO.

Diagram No. 26 was plotted from Table No. 49 and gives four curves, showing the proportion of the total tonnage entering the port of San Francisco from the period covered by Table No. 49 and carried in ships of certain maximum draught, breadth, length and net registered tonnage. The maximum length of ship plotted was 600 feet. The very large Atlantic liners are not included, because such ships have not as yet used the port of San Francisco, and also because it is impossible to fix their loaded draughts with certainty.

Use of Diagrams.

Diagram No. 25 should be used to fix the relative dimensions of harbor improvement projects. For example, if the maximum available depth for any project were limited then it would be possible to make a rational determination of the proper length, width and height of wharves or piers, and the proper width and depth of slips or channels.

Using mean values it will be seen that a ship with a 20-foot draught, for example, has an average length of 230 feet, breadth of 40 feet, and net registered tonnage of 1,250 tons. Similarly a draught of 25 feet corresponds to a breadth of 48 feet, a length of 400 feet and net registered tonnage of 2,350 tons.

Diagram No. 26 can be used in economic studies of harbor projects in San Francisco Bay. It shows the portion of the total volume of commerce which could be accommodated in any project having channels or piers with certain fixed dimensions, corresponding to maximum draught, breadth or length of the ships carrying the given portion of the total commerce.

The diagram, for example, shows that 45 per cent of the total tonnage entering and leaving San Francisco Bay is borne by vessels having a draught of twenty feet or less, and that 80 per cent is borne by vessels having a draught of twenty-five feet or less. Similarly 45 per cent is accommodated by vessels having a breadth of less than 41 feet and a length of less than 200 feet, and 80 per cent by those having a breadth of less than 50 feet and a length of less than 400 feet.

The tables and diagrams are not intended particularly to forecast the size of ships which will use the port of San Francisco in the future, and hence should be used with caution in designing permanent harbor construction work. The opening of the Panama Canal, which is designed for ships even larger than any at present constructed, will undoubtedly bring to San Francisco harbor a class

of shipping larger than has been coming in the past. This seems particularly certain because of the fact that a number of the largest steamship companies are even now seeking terminal facilities in San Francisco Bay, with the avowed object of running large ships direct from the Atlantic and European ports. The limit of length, breadth and speed has not yet been reached, but there appears to be a world-wide reaction against increasing the draught of ships. The Atlantic steamship lines continue to build larger and faster vessels, but the practicable limit is set by the enormous expense required in improving most foreign ports to accommodate the largest ships.

Sources of Information.

In the search for data for this Appendix the following authorities were consulted:

1. Lloyds' Register of Shipping, issued by committee of Lloyd's Register. Head office, London.

2. Firemen's Fund Register of Vessels, documented to the Pacific Coast of United States and Hawaiian Islands for the year 1911.

3. Statistics of steam schooners of the Pacific Coast, published by Ship-Owners' Association of the Pacific Coast, San Francisco, 1911.

4. Steamboat Inspection Service of United States, Department of Commerce and Labor.

5. Pilot Master for the Harbor of San Francisco.

6. Office Records of Ship-Owners and Operators.

7. Reports of the State Board of Harbor Commissioners.

Table No. 48—Principal Ship Measurements of Pacific Ocean and Other Steamers.

Vessel—Name	Owner or Agent	Net Tonnage	Length	Breadth	Depth	Draft
Adriatic	White Star Line	15,638	709.2	75.5	52.6	37' 3"
Alaskan	Am. Hawaiian S. S. Co	5,621	470.1	57.2	31.5	
Amerika	North German Lloyd	13,637	669.0	74.5	47.8	38' 6"
Arizona	Bowes & Andrews	1,105	....	....	....	20' 6"
Arizonan	Am. Hawaiian S. S. Co	5,621	470.1	57.2	31.5	27' 7"
Baltic	White Star Line	15,295	709.2	75.6	52.6	37' 3"
Belfast	Pope, Talbot Lumber Co	1,810	....	....	....	22' 6"
Bon Dorag	Pope, Talbot Lumber Co	2,193	....	....	....	21' 4"
Cedric	White Star Line	13,520	680.9	75.3	44.1	36' 8"
Celtic	White Star Line	13,449	680.9	75.3	44.1	36' 7"
Chiyo Maru	Toyo Kaisen Kaisha	7,250	558.0	61.9	*35.4	30' 0"
Columbian	Am. Hawaiian S. S. Co	5,598	472.3	57.2	32.3	31' 0"
Coos Bay	Pacific Coast S. S. Co	403	180.5	24.0	14.0	14' 0"
Drummuir	Pope, Talbot Lumber Co	1,798	....	....	....	21' 3"
Eureka	Pacific Coast S. S. Co	1,399	237.5	42.0	23.4	12' 4"
Fairhaven	Pope Talbot Lumber Co	437	185.5	38.0	14.0	17' 1"
Glencluny	Western S. S. Co. Ld	3,060	400.2	51.9	*17.8	23' 7"
Governor	Pacific Coast S. S. Co	2,401	391.9	48.2	19.7	24' 8"
Harvard	Pacific Navigation Co	2,317	376.0	61.3	20.2	19' 6"
Hanalei	Independent S. S. Co	780	174.5	36.0	13.0	16' 6"
Hercules	Shipowners & M. T. Co	200	134.9	26.1	15.5	16' 0"
J. D. Peters		788	206.5	38.0	8.1	6' 6"
J.M.McDonald	Cal. Nav. & Imp. Co	121	104.5	25.5	5.0	2' 0"
Kaiser Wilhelm II	North German Lloyd	6,353	684.3	72.3	40.2	
Kaiserin Augusta Vic.	Hamburg American S. S. Co	14,847	677.5	77.3	50.2	39' 10"
Leader		156	144.0	32.0	6.5	5' 0"
Leelanaw	Bates & Chesebrough	1,377	273.8	36.3	21.4	21' 0"
Mackinaw	Bates & Chesebrough	2,005	270.0	41.9	24.0	20' 11"
Manchuria	Pacific Mail S. S. Co	8,750	600.0	65.3	*43.3	33' 0"
Marquette	Atlantic Transport Co. Ld	4,536	486.5	52.3	*34.5	26' 11"
Mary E. Foster	Pope Talbot Lumber Co	839	202.2	40.2	15.9	19' 10"
Minnesota	U. S. Navy	13,324	622.0	73.5	*54.5	37' 2"
Missourian	Am. Hawaiian S. S. Co	5,077	491.5	58.2	*35.5	28' 6"
Mongolia	Pac. Mail S. S. Co	8,570	600.0	65.3	*43.3	33' 0"
Mountfields	Doughty Shipping Co. Ld	1,947	325.0	47.2	*24.8	20' 5"
Nippon Maru	Toyo Kaisen Kaisha	3,452	431.0	50.7	*32.5	26' 1"
Navajo	Bates & Chesebrough	1,711	258.0	42.0	19.0	20' 5"
Olympic	White Star Line	20,000	852.5	92.5	59.6	
Pres. Grant	Hamburg Am. S. S. Co	11,112	599.0	68.2	43.3	38' 4"
Pres. Lincoln	Hamburg Am. S. S. Co	11,171	598.8	62.2	48.3	38' 4"
President	Pac. Coast S. S. Co	2,393	391.9	48.2	19.7	25' 6"
Pennsylvania	Pac. Mail S. S. Co	2,567	343.0	43.0	24.9	25' 7"
Pleiades	Bates & Chesebrough	2,932	331.5	47.0	25.0	23' 9"
Queen	Pacific Coast S. S. Co	1,672	331.2	38.5	21.2	19' 8"
Repeat	Pope, Talbot Lumber Co	410	148.9	34.4	12.0	15' 4"
Riverina	Huddart Parker Ld	2,808	370.0	49.7	25.3	22' 5"
Riverside	Bates & Chesebrough	955	240.0	41.0	17.0	17' 10"

Table No. 48 (Continued)—Principal Ship Measurements of Pacific Ocean and Other Steamers.

Vessel—Name	Owner or Agent	Net Tonnage	Length	Breadth	Depth	Draft
Robert Lewers	Pope Talbot Lumber Co....	669	185.1	39.2	14.3	18′ 5″
Ramano	Pope Talbot Lumber Co....	631	.....	.....	.....	18′ 3″
S. C. Allen	Pope Talbot Lumber Co....	632	177.2	37.0	14.3	17′ 2″
Senator	Pacific Coast S. S. Co....	1,835	280.0	38.1	19.6	18′ 2″
Shanyack	Geo. Billings Co..........	400	.....	.....	.....	14′ 6″
Shinyo Maru	Toyo Kaisen Kaisha	257	154.4	20.7	16.4	29′ 3″
Sheridan	U. S. Army	3,654	.....	.....	.....	25′ 0″
Sna Yak	Pope, Talbot Lumber Co...	451	.....	.....	.....	17′ 9″
Spokane	Pope, Talbot Lumber Co...	570	183.0	38.5	13.2	22′ 6″
Stanley Dollar	Bates & Chesebrough	955	240.0	41.0	20.0	18′ 0″
Strathardle	Bordwell & Co.	3,126	.....	.....	.....	24′ 3″
T. C. Walker	Cal. Nav. & Imp. Co......	702	200.0	38.8	9.0	6′ 6″
Tahiti	Hind, Rolph & Co........	3,841	460.0	55.5	32.4	26′ 4″
Tampico	Bates & Chesebrough ...	1,451	247.0	42.0	24.0	20′ 0″
Tenyo Maru	Toyo Kaisen Kaisha	7,265	558.0	61.9	35.5	26′ 7″
Thor	Western Fuel Company ...	3,152	.....	.....	.....	23′ 6″
Tiverton	Pope Talbot Lumber Co...	336	155.0	36.0	12.7	16′ 6″
Topeka	Pacific Coast S. S. Co......	.....	.....	.....	.....	13′ 10
Winnebago	Standard Oil Co..........	2,927	360.0	49.7	28.7	27′ 0″
Yale	Pacific Navigation Co......	2,312	376.0	61.3	20.2	19′ 6″

*Moulded depth. All other figures give registered depth.
References: Lloyds' Register, Fireman's Fund Register, Office Records of Owners and Operators.

Table No. 49—Classification of Ocean Traffic Arriving at San Francisco Wharves During Fiscal Year 1909-1910.

SHIP TONNAGE

Class No.	Size of Vessel (tons)			Foreign Traffic	Coastwise Traffic	Total Traffic by classes	% of Total by class
1	Under	to	200	....	58,086	58,086	1.52
2	200	to	500	12,241	797,679	809,294	21.25
3	500	to	1,000	....	485,096	485,096	12.72
4	1,000	to	1,500	15,687	513,158	528,848	13.88
5	1,500	to	2,000	127,053	236,655	363,708	9.54
6	2,000	to	3,000	320,794	646,500	785,294	20.62
7	3,000	to	4,000	247,749	34,737	282,486	7.38
8	4,000	to	5,000	39,361	26,412	65,773	1.73
9	5,000	to	6,000	223,593	53,380	276,973	7.27
10	6,000	to	7,000	....	....	.....	.....
11	7,000	to	8,000	65,325	....	65,325	1.72
12	Over		8,000	89,050	....	89,050	2.34

Totals 1,140,833 2,679,704 3,810,566
Report of State Board of Harbor Commissioners, 1910.

APPENDIX No. IV

Direction and Velocity of Prevailing
Winds in San Francisco Bay

DIRECTION AND VELOCITY OF PREVAILING WINDS IN SAN FRANCISCO BAY

Source of Wind Data.

The United States Government maintains weather observation stations at various points throughout the United States. In the vicinity of San Francisco Bay the stations are maintained at San Francisco and San Jose. Wind conditions in the vicinity of San Jose, however, are so different from those along the coast that any records kept at that station do not bear directly upon conditions in the main part of San Francisco Bay. Therefore, all data used in this study is from the station maintained on the Merchants' Exchange Building at San Francisco.

The Government station is equipped with automatic instruments for recording the velocity of the wind, and its direction by segments of 45° for each five-minute period throughout the day. These records are kept permanently, and are open to the public for inspection. After looking over carefully the different records kept at the stations, it was decided that for the information desired it would be necessary to get a copy of the records giving wind direction and maximum velocity for some definite period. A three-year period was accordingly chosen covering the period from January 1st, 1909 to December 31, 1911.

Results of Study of Wind Data.

From the records copied, summations were made to the total miles of wind travel past the San Francisco station at a velocity of 15 miles or more per hour for each direction by 45° segments. This summation gives the following miles of wind travel past the station from the points of the compass:

North	N. E.	East	S. E.	South	S. W.	West	N. W.
0	1,865	0	1,709	4,502	25,637	31,969	1,594

These records have been platted (see two accompanying diagrams Nos. 27 and 28) so as to represent graphically a comparison of the wind travel in the different directions. Also on a separate sheet have been platted the direction and velocity of all winds

TO THE NORTH

TO THE NORTHWEST

TO THE NORTHEAST

TO THE WEST

TO THE EAST

MILES PER HOUR
10 MILES PER HOUR
20 MILES PER HOUR

TO THE SOUTHWEST

TO THE SOUTHEAST

TO THE SOUTH
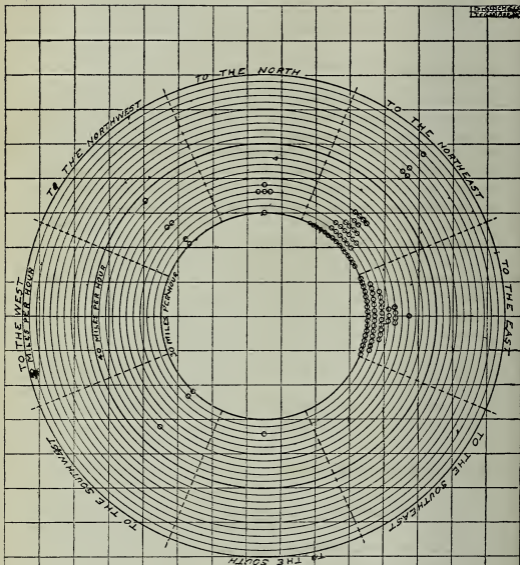
DIAGRAM #27
APPENDIX IV
SAN FRANCISCO BAY HARBOR STUDIES
DAILY WINDS
WITH VELOCITY OF 30 OR MORE MILES
PER HOUR AT SAN FRANCISCO
FOR
PERIOD JAN.1, 1909 TO JAN. 1, 1912
Sept. 1912

Compiled from U.S Weather Bur. Records

Haviland & Tibbetts, Engrs.
San Francisco.
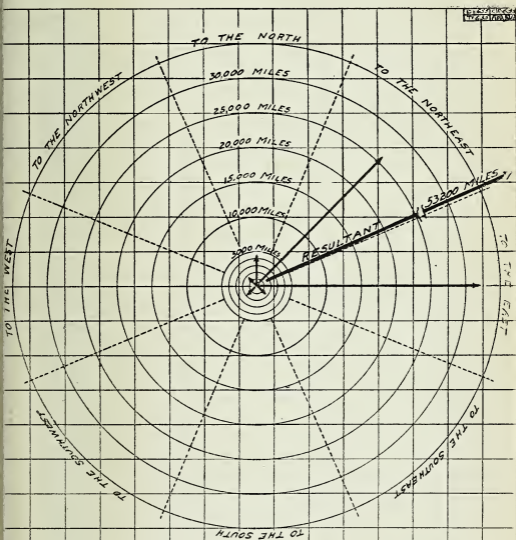
DIAGRAM #28
APPENDIX IV

SAN FRANCISCO BAY HARBOR STUDIES
WIND TRAVEL PAST SAN FRANCISCO
AT RATE OF 15 MILES OR MORE PER HOUR
FROM
JAN.1,1909 TO JAN 1,1912

SEPT 1912

Haviland & Tibbetts,
Civil Engineers,
San Francisco.

Compiled from U S Weather Bur Records

throughout the entire period that have a velocity of 30 or more miles per hour. The following tabulation gives the result of these maximum winds:

Velocity (per hour)	Direction	No. of Storms
40 miles or more	Northeast	4
35 to 40 or more	Northwest	1
35 to 40	Northeast	4
35 to 40	East	1
35 to 40	Southwest	1
30 to 35	North	5
30 to 35	Northeast	32
30 to 35	East	47
30 to 35	South	1
30 to 35	Southwest	3
30 to 35	Northwest	4

From Diagrams Nos. 27 and 28, giving the graphical representation of wind travel past San Francisco at a rate of 15 miles or more per hour, for the period between January 1st, 1909 and December 31, 1912, a very clear idea can be obtained of the relative amount of wind traveling in each direction. From this it is seen that the maximum wind travel was: 1st, to the east; 2nd, to the northeast, and 3rd, to the north. The wind travel in the other 45° segments is insignificant by comparison.

The resultant of the wind travel in the different directions shows a travel in a direction between northeast and east of 53,200 miles. This means that if an object were to start out from some point, and travel in the direction indicated, the number of miles indicated, it would eventually be at a point 53,000 miles in a direction between northeast and east from the point from which it started.

Effects of Wind Action.

One of the fundamental requirements of a good harbor is shelter and protection from storms, for shipping and for harbor improvements. The studies given above indicate that storms of destructive violence are practically unknown in San Francisco Bay. The highest velocity ever recorded by the weather bureau of San Francisco was 64 miles per hour. The highest velocity recorded in the three years studied is only 48 miles per hour. The next highest is 45, and, in fact, velocities in excess of 40 miles per hour were

recorded on only four different occasions in the three years. This is hardly sufficient to cause any appreciable effect on well built harbor works and it is only on very rare occasions that it has any disturbing effect on shipping.

The worst effect of the southwest storms is felt along the eastern shores of the bay, especially where the trend is northwest to southeast and where there are wide reaches of exposed water. In such locations it is occasionally necessary for ships to anchor out in the bay in order to prevent injury from pounding of wharves or ships. The San Francisco water front is so sheltered from the southwest that even this precaution is never required.

A secondary effect, however, of wind action, especially in shallow water is a slow shifting of the local topography. Even a moderate wind, if blowing continually in one direction, will cause in shallow water sufficient wave action to stir up the mud and sand along the shore and to keep it continually moving. Wind action in producing littoral drift of this sort is much less important than the action of tidal currents, but unless interfered with by the latter, is always present. This generally results in silting on the leeward side of the bay. If artificial barriers are placed in the path of the littoral drift they will stop the movement, and the water will shoal rapidly on the windward side, and sometimes to a lesser extent on the leeward side. If an artificial channel is dredged in shallow water and across the path of the prevailing wind, it will be quickly silted up, unless protected by some artificial barrier. In general the best direction for a dredged channel is parallel to the resultant wind and tidal currents. If not possible to make it so, the windward side at least should be protected by an artificial barrier. The effect of wind action on jetties or training walls is least where they are constructed parallel to the prevailing winds.

Appendix No. V

RESUME OF THE RICHMOND CITY CHARTER SHOW-
ING ORGANIZATION OF THE CITY GOVERNMENT
AND FINANCIAL CONDITIONS RELATIVE TO
BONDED INDEBTEDNESS

RESUME OF THE RICHMOND CITY CHARTER SHOWING ORGANIZATION OF THE CITY GOVERNMENT AND FINANCIAL CONDITIONS RELATIVE TO BONDED INDEBTEDNESS.

CHARTER OF THE CITY OF RICHMOND.

ARTICLE I.

(Boundaries)

(This article sets forth the charter boundaries of the city and provides that these boundaries may be altered by being added to or diminished in accordance with the laws of the State of California, for the annexation and exclusion of territory.)

ARTICLE II.

(Powers)

Section 1. The City of Richmond shall have and exercise the following powers:

1. To have perpetual succession.

2. To have and use a corporate seal and alter it at pleasure.

3. To sue and be sued in all courts and places, and in all actions and proceedings whatsoever.

4. To purchase, receive, have, take, hold, lease, use and enjoy property of every kind and description, both within and without the limits of said city, proper for municipal purposes, and to control and dispose of, the same for the public benefit.

5. To receive bequests, devises and donations of property of every kind, either absolutely or in trust for any purpose, and to do acts necessary to carry out the purposes of such bequests, devises and donations, and to manage, control, sell or otherwise dispose of such property in accordance with the terms of such bequests, devises or donations.

6. To exercise police powers and make all necessary police and sanitary regulations, and to adopt ordinances and prescribe penalties for the violation thereof.

7. To levy and collect taxes and assessments, impose license fees for revenue or regulation, and provide all means for raising the revenue necessary for the city.

8. To borrow money, incur municipal indebtedness and provide for the issuance of bonds or other evidences of such indebted-

ness for any purpose authorized by the electors voting on the proposition to incur such indebtedness; to invest the proceeds arising from the sale of bonds in street improvement bonds issued under any act of the Legislature.

9. To construct, maintain and operate all necessary works, light, heat and power, and to dispose of commodities produced or render service in connection with such work outside of the boundaries of said city.

10. To control the bays, inlets and channels flowing through the city or adjoining the same, to widen, straighten and deepen the same where such work is necessary for the purpose of sanitation, drainage or removal of sewage; to fill the same when they are obstructions to proposed streets or roads; to control and improve the water front of the city and to maintain embankments or other works necessary to protect the city from overflow; to construct and maintain wharves, chutes, piers and breakwaters within the limits of the city.

11. To establish and change the grade and lay out, open, widen, change, vacate, pave, repave or otherwise improve all public streets and highways and public places, construct sewers, drains, bridges, conduits, culverts and subways thereon or thereunder, to plant trees, construct parking, and to remove weeds; to levy special assessments to defray the whole or any part of the cost of such works of improvements. Also to provide for the repair, cleaning and sprinkling of such streets and public places.

12. To construct and maintain all works necessary for the disposition of the sewage, garbage and waste within the city and to define and abate nuisances.

13. To establish and maintain hospitals, indigent homes and all other charitable institutions.

14. To acquire and maintain parks, playgrounds and places for recreation.

15. To acquire and maintain markets, baths and public halls.

16. To establish and maintain schools, libraries, museums, and to do all things to promote the education of the people.

17. To equip and maintain a fire department and to make all necessary regulations for the prevention of fires.

18. To acquire, construct and maintain all buildings necessary for the transaction of public business.

19. To exercise the right of eminent domain for the purpose of acquiring real and personal property of every kind for any public use.

20. To grant franchises to use the streets or public property, and impose conditions in connection therewith.

21. To exercise any power conferred upon municipalities by the constitution and laws of the state to fix and establish rates to be charged by any corporation for any public service and regulate the quality of such service.

22. To exercise such other powers as may be hereafter granted by the Legislature to municipalities within the state.

23. To exercise all other needful powers for the efficient administration of the municipal government, whether such powers herein are expressly enumerated or not.

24. Lastly, this grant of power is to be liberally construed for the purpose of securing the well being of the municipality and its inhabitants.

ARTICLE III.

(The Council)

Section 1. All powers herein granted to and vested in the city of Richmond, shall, except as herein otherwise provided, be exercised by a council to be designated the council of the City of Richmond; and said council shall, except as herein otherwise provided, have the power to fix and establish the method and manner in which such powers shall be exercised.

Sec. 2. Said council shall be composed of nine members, each of whom shall have been an elector of the city of Richmond for at least one year next preceding his election.

The members of said council shall be known as councilmen, and their terms of office shall be six years commencing on the first day of July next succeeding their election, except that the terms of those first elected to serve as councilmen shall be as herein provided.

Sec. 3. On the second Monday of May, 1909, an election shall be held within said city for the purpose of electing nine members of said council.

The nine members elected at such election shall, at the first regular meeting, in July, 1909, so classify themselves by lot that three of said members shall hold office for the term of two years, three for the term of four years, and three for the term of six years.

Thereafter, on the second Monday in May, of each odd numbered year, an election shall be held at which the three councilmen shall be elected to succeed the three members whose terms ex-

pire on the first day of July next following; also to elect a member for any unexpired term that may exist.

The electors in form and manner prescribed in Section 2 of Article VIII, may by ordinance provide for the division of the city into districts or wards and require that one councilman to be elected at each election shall be a resident of each ward at the time of his election; provided that all councilmen shall be voted for at large.

Sec. 4.   The councilmen shall each receive the sum of five dollars for each day while sitting as a board of equalization; but no other compensation shall be paid unless the electors, by ordinance proposed and adopted in accordance with Section 2 of Article VIII, shall otherwise provide.

Sec. 5.   Said council shall fix the time and place for its regular meetings and adopt rules to govern its proceedings.

Sec. 6.   Five members of the council shall be necessary to constitute a quorum for the transaction of business; but a less number may adjourn from time to time and compel the attendance of absent members, and impose such fines as it may deem proper upon members refusing or neglecting to attend such meetings.

Sec. 7.   No ordinance shall be passed, no officer appointed or removed, no contract shall be awarded and no obligation incurred by the city in excess of three hundred dollars without the affirmative vote of at least five members of the council.

Sec. 8.   Said council shall elect one of its members as its presiding officer, who shall be known as mayor, to serve for one year after his election.   In the absence or disability of the mayor, a mayor pro tem. shall be elected.

The said mayor shall preside at all meetings of the council, shall be the chief executive of said city, and as such shall sign all contracts on behalf of the city, and perform such other duties as may from time to time be assigned to him by the council.   In all other respects he shall perform the same duties as any other member of the council.

Sec. 9.   The council shall appoint or provide for the appointment of a clerk, treasurer, auditor, tax collector, assessor, attorney, engineer, chief of police, and except as otherwise provided, such other officers, boards or commissions as may be necessary for the transaction of the affairs of the municipality.   It shall also appoint a commissioner of health and city physician, each of whom shall be a physician licensed to practice medicine.

Sec. 10. A vacancy in the counil shall be filled by a majority of the remaining members. Such appointees shall hold office until the first day of July succeeding the next election at which councilmen are to be elected. At the next election succeeding any vacancy a councilman shall be elected to serve for the unexpired term.

Sec. 11. The council shall by ordinance provide for the assessment, levy and collection of taxes, and shall act as a board of equalization in equalizing the value of property listed upon the assessment roll. During the month of September in each year, it shall levy such tax as may be necessary to raise revenue for the maintenance of the city and the several departments during the fiscal year, but such tax levy for all municipal purposes except the payment of interest and principal on any bonded debt and in support of the public schools, shall not exceed the sum of sixty cents upon each $100.00 of assessed valuation as the same appears upon the assessment roll. If in the judgment of the council it should be necessary to provide a revenue in excess of the sum realized from the levy herein provided, the question of the levy of an additional tax shall be submitted to the electors and a special election may be held for that purpose. The additional sum or rate required to be raised by such additional tax levy shall be expressed upon the ballot. If a majority of the votes cast upon such proposition shall be in favor of authorizing the council to levy such additional rate, then the council may levy the additional tax so authorized.

ARTICLE IV.

(Duties of Officers)

Section 1. Clerk—It shall be the duty of the clerk to keep a true record of the proceedings of the council and record the same in proper books kept for that purpose. He shall have power to administer oaths in connection with all matters relating to the municipality.

Sec. 2. Auditor—It shall be the duty of the auditor to act as bookkeeper and accountant of the municipality and shall record all financial transactions in books kept for that purpose. He shall draw warrants upon the city treasurer for all claims against the city which have been allowed by the council. He shall render each month a statement to the council showing the financial condition of the city, and annually a like statement covering all of the financial transactions of the city during the year previous.

Sec. 3. Tax Collector—It shall be the duty of the tax collector to receive and collect all moneys due the city for taxes and licenses and from other sources, and shall pay all money received into the treasury of the city, within twenty-four hours after the receipt thereof.

Sec. 4. Treasurer—The treasurer shall receive and safely keep all moneys belonging to the city and shall pay the same only upon warrants drawn by the auditor for the claims which have been previously allowed by the council or board of education, provided that the approval of the council shall not be necessary to pay the monthly salaries of employees. The treasurer may deposit all of such portion of the public money, as may be determined by the council, in any bank authorized by law to receive deposits of public money, in accordance with the provisions of the constitution and act of the Legislature entitled: "An act to provide for and regulate the deposit of county and municipal moneys in banks and banking corporations, limiting the amount of public moneys that may be deposited therein and providing a penalty for the illegal deposit and use thereof." (Approved March 23, 1907.) And the provisions of such act are hereby made applicable to the government of the City of Richmond.

Sec. 5. Assessor—It shall be the duty of the assessor to make annually a complete assessment of all property liable for taxation within the city between the first Monday of March and the first Monday of July next succeeding, and shall upon said last named date turn over to the city council the assessment roll so prepared by him. He shall act as tax collector for the purpose of collecting taxes upon personal property when the same are unsecured by a lien upon real estate.

Sec. 6. Attorney—The attorney shall act as the legal adviser of the council and any officer of the city when he requests his advice. He shall prepare all ordinances and contracts whenever required so to do by the council. He shall prosecute all violators of the city ordinances and shall represent the city in all actions.

Sec. 7. Engineer—The city engineer shall advise the council upon all matters of an engineering nature. He shall also be ex-officio superintendent of streets.

Sec. 8. Chief of Police—(Sets forth the duties and powers of this office.)

Sec. 9. Commissioner of Health—(Sets forth the duties and powers of this office.)

Sec. 10. City Physician—(Sets forth the duties and powers of this office.)

Sec. 11. (Provides for the furnishing of official bonds and for the appointment of deputies and assistants of the various city officials.)

Sec. 12. (Provides that all departments of government may appoint subordinate officers subject to the approval of and at a compensation to be determined by the council.)

Sec. 13. (Provides that the terms of officers appointed by the council shall be at the pleasure of the council and not to exceed two years.)

Sec. 14. (Provides that when the public interest requires, the council may consolidate any of the departments of government.)

ARTICLE V.

(Elections)

Section 1. (Provides that elections for councilmen and the board of education shall be held in accordance with the general laws of the state in so far as same are applicable under this charter.)

Sec. 2. (Provides for nominations of councilmen and members of the board of education.)

Sec. 3. (Provides for petitions and filing of petitions for nominations.)

Sec. 4. (Provides for the placing of candidates' names on the official ballot to be used at the election and also provides for primary elections of officers to be elected.)

Sec. 5. (Provides for the conduct of primary elections.)

Sec. 6. (Provides for the canvass of returns at such primary elections.)

ARTICLE VI.

(School Department)

Section 1. (Provides for the school department to be under the management and control of the board of education; provides for the election of members and the term of office; and said section also sets forth that the members of the board shall receive no compensation.)

Sec. 2. (Provides for board of education prior to the going into effect of the city charter.)

Sec. 3.   (Sets forth in ten paragraphs the powers and duties of the board of education.)

Sec. 4.   (Provides for a superintendent of schools and sets forth his powers and duties.)

Sec. 5.   (Provides that the board of education shall make an estimate of tax levy which shall be levied and assessed by the city council.)

Sec. 6.   (Provides for the control of the high school by the board of education.)

Sec. 7.   (Provides for the disposition of school funds.)

ARTICLE VII.

(Police Court)

Section 1.   (Provides for the creation of a police court.)

Sec. 2.   (Sets forth in two paragraphs the exclusive jurisdiction of the police court.)

Sec. 3.   (Sets forth the concurrent jurisdiction of the police court.)

Sec. 4.   (Provides for appeals from police court decisions.)

Sec. 5.   (Provides for rules of practice in the police court.)

Sec. 6.   (Provides for the payment of fines and other moneys received and collected into the city treasury.)

Sec. 7.   (Provides for the jurisdiction of the police court in the matter of actions existing at the time of the going into effect of the charter.)

Sec. 8.   (Provides that justice of peace may be police judge.)

ARTICLE VIII.

(The Recall, Initiative and Referendum)

Section 1.   (Provides for the recall of any elective office holder and for the procedure for same; and that the petition for recall shall be at least twenty-five per cent of the entire vote cast at the last preceding municipal election. The section further sets forth the qualification of the signatures of the petition at the time of filing certificate of examination of petition and finding it sufficient by the clerk; the fixing of a date for holding the recall election by the city council; the conducting of said election in accordance with the laws governing other municipal elections; the qualifications of candidates at such recall election; the election of the candidate receiving the highest number of votes at such recall election and the qualifications of the successful candidate; and the

termination immediately of the term of office of the officer recalled.)

Sec. 2. (Provides for the initiative. It sets forth the manner of submission to the council of any proposed ordinance; the petition which must accompany such proposed ordinance; the qualification of such petition by its containing ten per cent of the entire votes cast at the last preceding general municipal election; the reception or submission to the electorate of the proposed ordinance if the petition is signed by twenty-five per cent of all of said votes and contains a request to such effect that the ordinance must be submitted to a vote of the people at a special election rather than at the next regular municipal election. It sets forth description of the ballots, descriptions thereof, printing thereon; provides that the majority vote shall be deemed sufficient for the adoption of the ordinance; provides that the council may initiate an ordinance to be voted upon by the electors and limits the number of special elections to one in a twelve-month period.

Sec. 3. (Provides for the filing of a referendum petition within thirty days after the final passage of any ordinance or resolution in question. It further provides that any ordinance or resolution under referendum proceedings shall be suspended and inoperative until the election is held; and also provides that all proceedings relative to the submission of ordinance by initiative shall apply to ordinance under referendum proceedings.)

ARTICLE IX.

(Miscellaneous)

Section 1. (Provides for the ordinary clauses of all ordinances.)

Sec. 2. (Provides for the restriction of the powers of the council and the manner of exercising of powers of the council by initiative proceedings.)

Sec. 3. (Prohibits any officers of the city from being interested in any contract entered into by the city.)

Sec. 4. (Provides that no member of the council shall hold any other municipal office or any other office or employment, the compensation of which is paid out of municipal moneys, or that any officer be elected or appointed to any newly created office or to any additional compensation until one year after end of term of office to which the officer was elected.)

Sec. 5. (Provides for the grant of franchises along public streets, highways or public places in accordance with the provisions of the charter.)

Sec. 6. (Provides for the annual publication of the financial report of the city.)

Sec. 7. (Provides for liens for taxes.)

Sec. 8. ''No bonded indebtedness shall be incurred unless the same shall be first authorized by a vote of two-thirds of the electors voting at an election held for the purpose of voting on the proposition to incur such indebtedness; and no indebtedness incurred for the purpose of improving the water front shall at any time exceed six per cent of the assessed value of the property within the city.''

ARTICLE X.

(Time of Going Into Office)

(Provides that the charter is to go into effect on July 1, 1909, and further it provides that the officers prior to the taking effect of the charter remain in office until their successors in office are qualified.)

The charter is accompanied by the certificate of the Board of Free Holders, the city clerk, the president and clerk of the board of trustees and the approval of the Legislature.

RESOLUTIONS OF LEGISLATURE.

Approving the Charter.

The above Richmond charter was approved by an assembly concurrent resolution No. 11 of the Legislature of the State of California, adopted March 4, 1909. This resolution sets forth that the City of Richmond contains a population of between thirty-five hundred (3,500) and ten thousand (10,000); that a special election was held on the twelfth day of October, 1908, at the City of Richmond, in accordance with the laws of the State of California, in which a board of fifteen free holders duly qualified, was elected to prepare and propose a charter for the city; that the said board of free holders did propose a charter within ninety days after such election; that said charter was duly submitted in proper form; that said charter was duly published on the ninth day of February, 1909; that said charter was submitted to a special election of the voters of Richmond; was duly carried by a majority of votes voted at such election by qualified electors of the city; that said election was duly canvassed and the charter declared carried by the board of trustees of Richmond; that such charter was duly submitted to the Legislature of the State of California and duly ratified by such Legislature.

Appendix No. VI

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Engineering Organization

Engineering Organization

This report is submitted by P. A. Haviland. The data, conclusions, drawings and findings contained therein have been prepared under his supervision by the engineering firm of Haviland & Tibbetts, civil and consulting engineers of San Francisco, composed of P. A. Haviland, F. H. Tibbetts, O. W. Jasper, Jr., G. A. Posey and F. R. Hamilton.

The collection of data, the prosecution of surveys and the economic studies of the harbor designs have been prosecuted over a period of about nine months, from January 1, 1912, to September 15, 1912. As soon as the studies were sufficiently far advanced to indicate in a general way the probable requirements of Richmond, Mr. P. A. Haviland and Mr. Fred H. Tibbetts made a somewhat extended tour for the purpose of examining harbor works and terminal improvements at the principal sea and lake ports of the United States and many of the important seaports of Europe. Mr. P. A. Haviland visited the ports of New Orleans, Chicago, Toledo, Cleveland, Philadelphia, Baltimore, New York, London, Plymouth, Liverpool, Le Havre and Venice, and Mr. F. H. Tibbetts visited the ports of New Orleans, Chicago, Duluth, Milwaukee, Detroit, Toledo, Cleveland, Buffalo, Philadelphia, Baltimore, New York and Boston.

The compilation and collection of data has been chiefly under the supervision of T. D. Kilkenny, as project engineer, who has devoted his entire attention to the project since the work was first inaugurated.

The architectural treatment is due to Mr. Wm. Reed, assisted by Mr. J. A. Magee.

The estimates of land values are by F. R. Hamilton.

Others who have assisted in the office work are: Mr. B. Wuth and Mr. I. H. Smith, chief draftsmen; Mr. F. D. Andrews, Mr. H. R. Angwin, Mr. E. E. Boalt, Mr. W. D. Boggs, Mr. E. W. Burroughs, Mr. W. F. Cunningham, Mr. A. J. Eddy, Mr. W. S. Edwards, Mr. E. G. Finley, Mr. R. W. White, Mr. J. W. Fitting, Mr. F. F. Hall, Mr. H. L. Hammond, Mr. J. W. D. Jensen, Mr. J. S. Prell, Mr. C. E. Richardson, Mr. A. E. Robertson, Mr. G. S. Strout, Mr. S. R. Van Wyck, Mr. D. Wardin, Mr. A. M. Wells, Mr. E. T. Williams.

The field surveys and borings have been made chiefly by Mr. H. R. Church, Mr. J. L. Freeman, Mr. A. E. Powell, Mr. C. W. Randall, Mr. H. Touhy, Mr. V. H. Wikander, Mr. W. E. Yocum.

The writers wish to express their appreciation of the hearty co-operation and assistance of the Mayor, J. C. Owens, the members of the council, Messrs. E. J. Garrard, J. B. Willis, H. L. Penry, J. J. Dooling, Edward McDuff, G. A. Follett, O. R. Ludewig, J. N. Hartnett; City Clerk, Mr. I. R. Vaughn; City Attorney, Mr. Lee D. Windrem; City Auditor, Mr. J. A. McVittie; Tax Collector, Mr. I. E. Marshall; Treasurer, Mr. L. G. Bonzagni, and other officials of the City of Richmond, who have rendered valuable assistance in supplying the necessary data.

The willing and timely support of the City Engineer, Mr. W. S. Farley, has greatly facilitated the early completion of the report. To Mr. H. D. Chapman, civil engineer, acknowledgment is due for valuable assistance.

Special acknowledgment is due to Colonel Rees and his able assistants in charge of the development of the Government plans for the Richmond harbor work, whose valuable co-operation and assistance have been at all times of the greatest help in the development of the plans for the present project.

Supplementary Report on Tunnel
and Roadway

Review of Street Plan and Existing Railroad Lines of Richmond

(See Plate 3)

The topographic features of the City of Richmond are discussed in detail in Chapter V and the local lines of communication in Chapter XI. The city is divided by a central marshy zone extending in a general north and south direction, into an eastern and western section. The western section is on the eastern slope of the Potrero hills and includes the first developments which took place in Richmond. Here a distinct industrial, factory and business development has been concentrated on an area extending about three-quarters of a mile northwest of the Santa Fe Railroad. The eastern, or newer section, has developed its business center along Macdonald Avenue, from Fourth to Seventeenth Streets, confined in an area two blocks wide with Macdonald Avenue in the center. There is a scattered residence section extending several miles north, northeast, south, east and southeast from this center. A number of factories have developed along the line of the Southern Pacific Railroad south of Macdonald Avenue.

The railroads in the City of Richmond form a letter "A," with its apex near the northern boundary of the city, where the Southern Pacific crosses the Santa Fe. From this point the Santa Fe extends in a general southwesterly direction through the north central factory portion of the city, the western factory portion adjacent to the Standard Oil works and along the southeasterly edge of the developed section of Point Richmond. It then extends in a tunnel through the Potrero hills and in practically a straight line to the terminal wharves and ferry slips at Point Richmond, where the traffic is transferred on ferries to the City of San Francisco. The Southern Pacific extends from the apex of the letter "A" in a general southeasterly direction through the recently developed portion of the city, to Berkeley and Oakland. The Richmond Belt Line Railway begins at the apex of the letter "A," skirts the southern edge of the San Pablo marsh lands, runs around Point San Pablo, along the water front, southeasterly along the outer edge of the Potrero hills to the California Wine Association wharf at Winehaven. The main traction line of the East Shore and Suburban Railroad extends along Macdonald Avenue from San Pablo Avenue near the eastern boundary line of the city, due east and west through the center of the newer settled section to the

Santa Fe Railroad, then turns and parallels the Santa Fe Railroad, finally crossing the same and extending into the older, or Point Richmond district, through the Scofield Avenue cut to the San Pablo quarries at Point Castro. About 1,500 feet south of Macdonald Avenue the Oakland branch of the Santa Fe extends in an east and west direction from a point near Point Richmond, crossing the Southern Pacific at about Twenty-Third Street.

It will be seen that Macdonald Avenue, the principal street of the eastern section, forms between the railroads, the bar of the letter "A." Parallel to Macdonald Avenue, and nearly three-quarters of a mile south, near the base of the letter "A," Cutting Boulevard extends across the town from the eastern boundary line near San Pablo Avenue due west to the center of the Point Richmond section. This is a street 100 feet in width, affording the most direct line for traffic entering the City of Richmond from the foothill section, and from the cities of Berkeley and Oakland, to the south. Ashland Avenue is now being developed paralleling the Santa Fe from Macdonald Avenue northwesterly to the Point Richmond section, forming a broad boulevard directly connecting the centers of population of Richmond. Along the eastern base of the Potrero hills, Standard Avenue and Richmond Avenue are the main thoroughfares leading northwesterly from the junction of Cutting Boulevard and Ashland Avenue, and the Santa Fe Railroad. The traffic from the eastern section is taken by Ashland Avenue from Macdonald Avenue to this junction. The traffic from the southern section and the cities of Berkeley and Oakland is taken by way of the Cutting Boulevard, and the traffic from Point Richmond section is brought to the same point by way of Richmond Avenue and Standard Avenue, two blocks northeast. The principal recent developments of Richmond lie within the letter "A," between Cutting Boulevard and Ashland Avenue and its extension. The most available level areas for industrial development, particularly if the inner harbor project is carried through, will lie to the south of Cutting Boulevard and will use that street in reaching Point Richmond. There will probably also be further developments along the outer side of the Potrero hills in the territory served by the Belt Line Railroad.

Available Location for Deep Water Harbor Development.

The water front of Richmond has been described in detail in Chapter VI and the existing harbor improvements in Chapter II. Deep water is available along the Richmond water front only at

projecting points. In the bays between the projecting points are long reaches of shallow water and the pierhead line is so located that deep water can only be reached by piers of excessive length. The western edge of the Potrero hills is so precipitous that there is little opportunity for industrial development except by filling in the long reaches of shallow water back of the bulkhead line. Practically all of the private harbor developments have taken place at the various projecting points as shown in detail in Table No. 18, Page 76. The first location available north of the Point Richmond section is Point Castro, which is nearly two miles distant, and at which point the pierhead line is 2,000 feet off shore.

By a process of elimination, it is evident that the most practical location for immediate development of an outer, deep water, harbor is at Point Richmond. This point is nearer the developed portion of the city than any of the other projecting points along the water front. The bulkhead and pierhead lines are relatively close to the shore, and comparatively deep water is available. As the Santa Fe occupies the northern side of Point Richmond, new harbor developments must occur on the opposite, or southern side. This again is favorable because of the fact that the new Government project will result in the dredging and maintenance of a channel at this point, and will by the construction of a training wall, provide partial shelter.

Location of Connecting Roadway.

It has been shown that railroad, vehicle, passenger and freight traffic to obtain a water outlet on the west must come to the Potrero hills. The present and the probable future traffic lines of the City of Richmond will converge at a single point at the intersection of the Santa Fe Railroad, Ashland Avenue, Cutting Boulevard and Richmond Avenue.

It has also been shown that the most available deep water exists on the south side of Point Richmond and that this is the only deep water capable of immediate and economical development within a reasonable distance of the present centers of population in Richmond. Plans have been prepared in detail for the construction of a modern deep water wharf on the south side of Point Richmond as shown in the body of this report. These plans conform to a recommended Government project for the dredging and maintenance of a channel at this point. It must be at once evident that to obtain the advantages desired from the harbor project, it will be necessary to connect the outer wharf with the point at

which the present traffic converges, as previously described. This problem should be economically and permanently solved by the construction of a highway between the points named and where the height of the Potrero hills becomes too great for open cut, a tunnel should be constructed of sufficient capacity to accommodate the probable traffic.

There is at present a roadway leading from the traffic focus toward Point Richmond and crossing the ridge by a long and tortuous route involving prohibitive grades. The Santa Fe Railroad has a tunnel through the Potrero hills paralleling the route proposed for the present highway tunnel. This is timber lined, unlighted, unpaved and of sufficient size to accommodate the large railroad traffic only. There is considerable foot travel through the tunnel, but this is not encouraged or recognized.

The proposed highway and tunnel should lead in the most direct line practical from the traffic focus to the proposed wharf on the south side of Point Richmond. The highway and tunnel should be of permanent construction, of a size sufficient to accommodate the probable future traffic, and should afford the greatest assistance to heavy traffic by the elimination of steep grades and sharp curves. The tunnel should have sufficient width and height for light, ventilation and the separation of traffic. It is desirable to avoid as far as possible grade crossings of the Santa Fe Railroad.

Alignment of Roadway and Tunnel.

The proposed highway should commence on the southwestern line of Richmond Avenue, between Oregon Street and the Santa Fe Railroad and should be constructed as an open cut as far as practical, then should pass through the hills by means of a concrete-lined tunnel, paralleling the Santa Fe, and with its center line distant about 90 feet easterly from the center line of the Santa Fe tunnel. The tunnel will be in a general north and south direction, with its north portal facing the city and its south portal facing Point Richmond. From the south portal a highway should be constructed around the shore line east of the Santa Fe, and through a deep cut at Point Richmond to the north line of the proposed 150-foot street along the rear edge of the wharves and piers in Division No. 1 of the Richmond harbor. From the southern shore line of Point Richmond to the 150-foot street, the new roadway will be constructed upon a suction fill. The location of the outer wharf is such that it will be normal to the end of the highway, with its

center opposite. The total length of roadway will be approximately 6,400 feet, of which 725 feet will be in tunnel. Between the south portal of the tunnel and the cut at Point Richmond, the alignment swings eastward, following the shore line. A more direct alignment paralleling the Santa Fe is impractical, because the railroad, which owns the submerged land, proposes to reclaim it for switching yards. This would make the probable cost of condemnation prohibitive, and would mean that in the future the highway would have to be set back, or else cross switching tracks of the railroad. The increase in length of the roadway, because of following the shore line is less than 400 feet. The proposed alignment will eliminate any possible railroad crossings and will enable the highway to be constructed on solid ground throughout, thus decreasing the probable cost for maintenance or renewals. The tunnel goes underneath the Santa Fe reservoir on the top of the Potrero hills. The depth of cover at this point, however, is nearly 150 feet over the top of the tunnel, so that the construction work should not in any way damage the reservoir.

Development of West Side of Potrero—Overhead Crossing at South Portal.

The location of the proposed highway and tunnel should cause the immediate development of a residence section which has at present been started along the western slope of the Potrero hills. The grades are fixed so that at the south portal of the proposed tunnel a street may be constructed crossing over the portal of the Santa Fe tunnel and connecting with Front Avenue, which now extends along the shore line of the western slope of the Potrero hills. This will afford a direct and practical level, eastern outlet for the section of the city on the western slope of the Potrero hills and should lead to its rapid development as a residence district. If it is ever desired to develop harbor works on the bay section lying north and west of Point Richmond, then the overhead crossing connecting with Front Avenue will afford a direct access to such harbor development.

Location of North Portal of Tunnel.

The north portal of the tunnel and the north end of the highway is so located that traffic coming to the focal point will be afforded an outlet to the water front without crossing the tracks of the Santa Fe. This means that the outer wharves can be reached

by all of the Richmond traffic except that originating in the Point Richmond section north of the Santa Fe, without any railroad grade crossings. Plate 10 shows a suggested change in the alignment of Oregon Street so as to afford an overhead crossing over the north portal of the proposed tunnel, and the Santa Fe tunnel.

This will permit egress from the residence section of the Potrero lying on the eastern slope of the hill into Ashland Avenue and Cutting Boulevard without crossing the Santa Fe at grade. This change of Oregon Street should be accompanied ultimately by the construction of a concrete stairway for pedestrians at the north portal of the tunnel, leading from the tunnel sidewalk to Oregon Street. The traffic originating in the Point Richmond section must cross the Santa Fe either at Richmond Avenue or farther to the northeast at a proposed extension of Standard Avenue. As an ultimate development it is proposed that under grade crossings be constructed at some time in the future on an extension of Standard Avenue underneath the Santa Fe.

ROADWAY.

Grades.

The profiles of the proposed roadway and tunnel are 2.12 per cent, leading from the junction of Cutting Boulevard, Richmond Avenue and Ashland Avenue, through the tunnel to the south portal. The elevation of Richmond Avenue is 14 feet and the elevation at the south portal of the tunnel at Station 13 plus 40 is 42.5 feet, which is the highest point anywhere on the proposed project. The above are curb line elevations. The south portal of the tunnel is brought to this elevation in order to afford the desired crossing over the portal of the Santa Fe tunnel to give access to the western slope of the Potrero hills. From this point the roadway descends on easy grades, the heaviest of which is 2 per cent, to elevation 14 at Station 33, at which point it is intended to collect the drainage water from both directions. From Station 33 to Station 64 at the outer end, the heaviest gradient is 0.1 per cent. From Station 33 to Station 36 plus 50 the roadway ascends to elevation 14.90. From Station 36 plus 50 the roadway descends to elevation 14.30 at Station 42 plus 50. From here the gradient again rises to elevation 15.65 at Station 56. From Station 56 the grade again falls to the south end of the roadway. The profiles shown on Plates 10 and 11 are center line profiles.

Widths.

The highway as it leaves Richmond Avenue will be 60 feet in width, with 8-foot sidewalks on each side, leaving 44 feet between

curbs. This width will extend southerly in open cut for a distance of approximately 600 feet, to the beginning of the tunnel, which has a horse shoe section with a width between curbs of 27 feet, and a maximum width at the springing line of 35 feet. At the south portal of the tunnel the 600-foot roadway will again commence and will continue to the outer end. The sidewalk of the highway south of the tunnel section on the west side is to be 8 feet in width, and on the east side 4 feet in width, leaving 48 feet between curb lines. The width of 8 feet on the west side of the outer portion of the roadway is the total sidewalk area. The cement walk will be constructed 7 feet wide. A wider sidewalk is placed on the outer side because pedestrians will prefer that side on account of the unobstructed outlook over the water and the high bank on the opposite side. On the north end of the roadway, the east side of the highway has an 8-foot sidewalk area, with a 7-foot cement sidewalk for connection with the future stairway to Oregon Street.

Cuts.

About 380 feet from the north portal of the tunnel the roadway will be in open cut, with a maximum depth of about 40 feet. From the south portal to Station 29, the roadway will be in open cut except for a distance of about 270 feet, where it crosses a deep draw between Station 20 and Station 23. From Station 30 to Station 55 the roadway is in side hill cut except for two abutting points at Stations 36 and 46, which will be in thorough cut not exceeding 20 feet on center line. From Station 55 to Station 60 through the Point Richmond hill the roadway will be entirely in thorough cut, reaching a maximum depth on center line of about 55 feet. Between Stations 20 and 23 the roadway will be supported by a retaining wall in order that the fill on the lower side will not encroach on the Santa Fe spur track paralleling the highway and crossing it at Station 31 plus 10. The retaining wall is to be of gravity section as shown in detail on Plate 13, with an average height of 10 feet, and will be constructed of concrete.

Drainage.

Heavy concrete curbs, gutters and sidewalks will be constructed throughout the length of the roadway. The gutter area will have a width of 2½ feet, with a finish of smooth cement grout. Catch basins and drains are provided at the low points on either gutter line to conduct storm water into the bay. The drains are to be constructed with vitrified pipe jacketted with 6 inches of concrete.

Surfacing.

The pavement has been designed to give the greatest possible permanence. It will be constructed of reinforced concrete surfaced with asphalt. Expansion joints are provided in order to prevent excessive cracks developing.

Concrete will be reinforced with steel wire mesh. The curbs will be of concrete armored with 3-inch steel straps so as to prevent injury from traffic. The asphaltic cement surface will be one-quarter inch in thickness and is provided in order to eliminate the glare which usually results from concrete pavements, to deaden the noise which results from any hard pavement, and to lessen the wear on hard tires and horses' feet. This asphaltic cement surfacing can be renewed from time to time at a low cost. Renewal should not be more frequent, however, than 4 or 5 years, depending on the amount of traffic.

As an alternate surfacing the specifications provide for an asphaltic brick pavement with a base of red brick.

Grading.

Much the larger portion of the proposed highway is in cut, and hence will offer a hard surface for the immediate construction of a permanent pavement. The material in general will be a shale rock, partially disintegrated, and capable of standing on steep slopes. In order that there may be no danger of future disturbance from slips the grading will be finished with slopes of 1 on 1 in cut, and 1 on 1½ in fill.

Right of Way.

The total right-of-way required for the tunnel and highway is approximately 20 acres. A portion of this, north of the tunnel is partially improved and includes the location of an oil well at present under construction, so that the cost will be relatively high. It may not be necessary to acquire the fee in all of the land over the proposed tunnel as its construction will leave the surface unimpaired. The balance of the land, south of the tunnel is chiefly the property of the Santa Fe Railroad and is mostly unimproved. The minimum width of the right-of-way of 100 feet extends from Richmond Avenue to a point near the south portal of the tunnel. From here the right-of-way has an irregular width of 100 to 160 feet, being adjusted to meet the immediate demands of the road and tunnel construction, so as not to acquire any unnecessary land.

PROPOSED TUNNEL.

Location and Length.

The alignment of the proposed tunnel is shown in detail on Plate 10, and is also shown on Plates 3 and 4. It has been described in general in the description of the alignment of the proposed highway. The total length is 725 feet between portals, extending from Station 6 plus 15 to Station 13 plus 40.

Grades.

The grade is 2.12 per cent, sloping uniformly from the south portal with a curb line at elevation 42.5, the highest point on any portion of the proposed roadway, to the north portal, with a curb line at elevation 27.03. The maximum grade on the north approach is 2.12 per cent and on the south approach 2 per cent. All of these grades are so low that they will not inconvenience any class of traffic.

Cross Section.

The tunnel is to be concrete lined throughout, with a heavy lining having a minimum thickness of arch ring of 2 feet. The section is to be of horse shoe shape as shown in detail on Plate 12, with a maximum width of 35 feet at a point 5 feet above the curb grades. This section was chosen in order that when vehicles with considerable overhang were using the tunnel, the curb grades would prevent collision with any point of the tunnel lining. The width is such that the construction of railroad tracks as indicated will not reduce the width of the highway to an extent which will inconvenience vehicle or motor traffic. Approximate clearances for the largest size vehicles which might be expected are shown in Diagram No. 29. The total height from floor line to roof at the center of the tunnel is 22 feet 6 inches. Should a car line be constructed in the location indicated, the net clearance from the car line to the west curb would be nearly 17 feet. The curb is 1 foot in width, and the horse shoe section slopes back so that an additional 8 inches of width is gained at the spring line of the arch, five feet above the curb grades. This will give a net width when cars are passing through the tunnel of about 18½ feet for other vehicles. The total width between curb lines is 27 feet.

·RICHMOND· HARBOR REPORT PAGE ·267a·
SUPPLEMENTARY REPORT ON· TUNNEL & ROADWAY

LOWEST RUNNING POSITION OF TROLLEY

10'-5⅞"

6'-3"   15'-10"
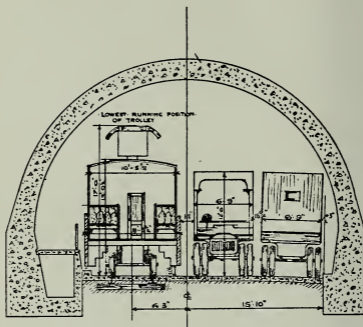
DIAGRAM № 29
· CLEARANCE· DIAGRAM
·FOR·
·RICHMOND· TUNNEL

·SHOWING LATEST TYPE OF·
·ELECTRIC CAR· AND TWO· MOTOR TRUCKS PASSING·

·SEPT 1912·
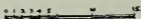
0 1 2 3 4 5   10   15·
SCALE 2 FEET = ONE INCH·

HAVILAND & TIBBETTS,
CIVIL· ENGINEERS,
SAN· FRANC·SCO·

Sidewalk.

Along the west line of the tunnel a 5-foot concrete sidewalk is to be built, raised 3 feet above the floor. The construction is such that there will be a net clearance of 4 feet 2½ inches. On the outside is to be a hand rail of galvanized iron pipe, with 3-inch vertical posts, 10 feet apart, and with two horizontal lines of 2-inch rail, spaced 1 foot 6 inches and 3 feet high respectively. On the sidewalk floor at the inside, a gutter drain will be provided, so as to drain the sidewalk of any seepage water which might come through the tunnel lining. The sidewalk is to be of concrete 6 inches in thickness, reinforced with one-half inch square bars at 6-inch centers. The surfacing will be of cement. At either end of the tunnel the sidewalk will descend to the street level on inclines, in a distance of 38 feet at the north portal, and 24 feet at the south portal.

Conduit.

The elevated sidewalk slab is supported by a vertical wall on the outside and by the concrete tunnel lining on the inside. The conduit formed under the sidewalk will be 3 feet 4 inches in width at the base and 4 feet at the top, with a clear height of 5 feet. This will afford a convenient space with ample room, for electric conduits, gas mains, water pipes, telephone or telegraph conduits, sewers, steam pipes, or any other similar structures. The pipes or conduits can be hung on iron rods, placed transversely through the conduit, or in any other convenient manner. The conduit will be entered by means of three manholes, one at either end of the tunnel, and one in the center. This will permit of a reasonable amount of air circulation, and will also permit of easy installation, alteration, or repairs to any of the cables or equipment installed. The manholes will be provided with sound deadening covers, and will not materially break the contour of the sidewalk.

Drainage.

Seepage water from the tunnel is to be led by weep holes constructed in the concrete lining to the gutter area on the east side and to a semi-circular drain in the floor of the conduit under the sidewalk on the west side. Weep holes are also placed in the vertical wall supporting the outer edge of the sidewalk extending to a broken rock section provided underneath the floor of the tunnel for future railway ties. At the north portal of the tunnel the

drain in the center of the conduit will be taken diagonally across to the east side of the proposed highway, where it will discharge into the street gutter. The floor of the tunnel has a fall of 6 inches from the west curb to the east curb, and is designed to conduct drainage water to the east gutter, which will lead it to the north portal of the tunnel.

Future Railroad Provision.

The center of the proposed railroad track is to be 6 feet 3 inches from the center of the tunnel. The areas designed to be eventually occupied by the ties should be filled with broken rock underneath the floor of the tunnel. This will permit of the future construction of the railway at a minimum cost, and with the least possible inconvenience. This broken rock section will also collect drainage water underneath the floor as shown above.

Curbs.

The curb on the west side of the tunnel is 6 inches higher than that on the east side in order to provide drainage as described. Both curbs are 6 inches high and 12 inches wide, and are armored with a steel strap, 3 inches in width.

Lighting.

The tunnel is to be lighted with a system of electric lights designed to eliminate as far as possible the shadows from passing traffic. The wires for lighting purposes will be carried along the roof, and not embedded in the concrete, in order that the concrete lining may not be weakened, and in order to facilitate operation and repairs.

Portals.

The portals at either end of the tunnel are to be granite faced, and the wing wall is extended at the south portal to accommodate the future proposed road to cross over the Santa Fe tunnel. The narrowing of the streets at the tunnel portals will be effected by gradually converging the street improvement lines, so the traffic will come naturally and easily to the tunnel.

Disposal of Material.

The highway has been located with a view to the economic disposal of the excavated material with the least practicable haul. The material taken from the south portal of the tunnel may be wasted in the shallow water areas across the Santa Fe to the

southwest, with a view of eventually utilizing it as a portion of a possible fill toward the bulkhead line at this point. Otherwise the excess material might be offered to the Santa Fe Railroad to reclaim a portion of their submerged land lying between their tracks and the proposed highway, as a partial compensation for the lands to be taken.

Future Duplication of Tunnel.

Should the traffic outgrow the capacity of the proposed tunnel, it could be duplicated in the future, either close to the present site, or at any other convenient location. The size of the present cross section is close to the economic limit for this class of structure, so that even though it were evident that the traffic requirements would not be met, it would probably be desirable to construct another tunnel rather than to greatly increase the size of the one proposed.

Proposed Financing of Tunnel and Roadway Project.

The cost of the construction of the tunnel and roadway should be a charge against the entire city. This is proper, because it affords the only practicable western outlet to deep water and the proposed outer wharf, which should be of about equal value to all parts of the city. Great increase of value will result along the line of the highway, along the outer edge of the Potrero hills, and in property adjacent to the north portal of the tunnel.

Every effort has been made to design the entire structure of the most permanent character, so that long-term bonds are recommended for its payment. These, like the harbor bonds, should be of maximum length, preferably 40 years, 5 per cent bonds.

Period of Construction.

The greatest time will be taken by the construction of the tunnel, due to its large cross section and heavy lining. This work could be prosecuted, however, at either end, especially if the south heading were driven of sufficient size to permit transporting excavated material to the south portal, near which it is to be disposed of. With this method of construction in view it is estimated that the entire project could be completed within a period of twelve months.

Annexed Specifications and Proposal Sheets.

Accompanying this report are complete working drawings with the following papers:

1. Notice to bidders.
2. Proposal sheets.
3. Contracts.
4. Specifications.
5. Contractor's bonds.
6. Detailed Plans.

The specifications have been drawn in order to provide the highest possible type of construction work with the greatest economy and speed of construction.

The contract and other papers are drawn in such a way as to afford the city the best possible construction and ample protection in all possible contingencies. With the careful supervision, which it is presumed will be accorded this project, the most permanent and efficient work should be assured.

Cost Estimates.

The total cost of construction of the tunnel and highway complete, and including a 10 per cent allowance for engineering, supervision, legal costs, incidentals and contingencies, is $366,300.00.

The total costs of rights-of-way and property damages for the tunnel and roadway complete, including an allowance of 10 per cent for legal costs, condemnation suits and contingencies, is $64,462.00.

Total for tunnel and highway project, including rights-of-way, $430,762.00.

SUMMARY AND RECOMMENDATIONS.

1st. The street plan and railroad location of Richmond is such that the present and probable future traffic arteries intersect at a point on the eastern slope of the Potrero hills, near the north portal of the Santa Fe tunnel; these principal traffic arteries being Cutting Boulevard, Ashland Avenue, Richmond Avenue and the Santa Fe Railroad.

2nd. Richmond's industrial development is such that an outer deep water harbor is imperative. The topography permits of but one practical location for such an outer deep water harbor, this location being at the outer end of the proposed Government harbor

improvement and at the site of the proposed outer wharf on the south side of Point Richmond.

3rd. The construction of the proposed outer wharf and the Government harbor improvements will necessitate the construction of a highway leading from the traffic focus to the site of the outer wharf at Point Richmond.

RECOMMENDATIONS

It is recommended that a permanent modern highway and tunnel be constructed along the alignment indicated. The highway should be located with light grades (not exceeding 2.12 per cent) and easy curves, passing through the Potrero hills in a concrete-lined tunnel, the width of the highway in the main being 60 feet, with sidewalks on either side, giving a clear width between curbs of 44 and 48 feet; the tunnel to be constructed with a horse shoe section, with a maximum width of 35 feet, and the width between curbs of 27 feet, as shown in detail; a 5-foot sidewalk to be located so as to give a convenient conduit for pipes and wire, provision to be made for a future railway track.

The estimated cost of construction work on highway and tunnel is $366,300.00, and of the rights-of-way for the same is $64,462.00, making a total of $430,762.00. It is recommended that the cost of the construction work be met by a bond issue, covering the entire city, and that the costs of the rights-of-way be either included in the bond issue as above, or be met by the formation of a large assessment district under the street opening act of 1889 or 1905.

As it is desirable to provide some margin in any bond issue for unexpected contingencies it is recommended that in the former case 40-year, 5 per cent bonds be issued for $375,000.00, and if the rights-of-way are to be included that the 40-year, 5 per cent bonds be issued for $440,000.00.

<div style="text-align:right">

(Signed)   P. A. HAVILAND,

Engineer.

</div>
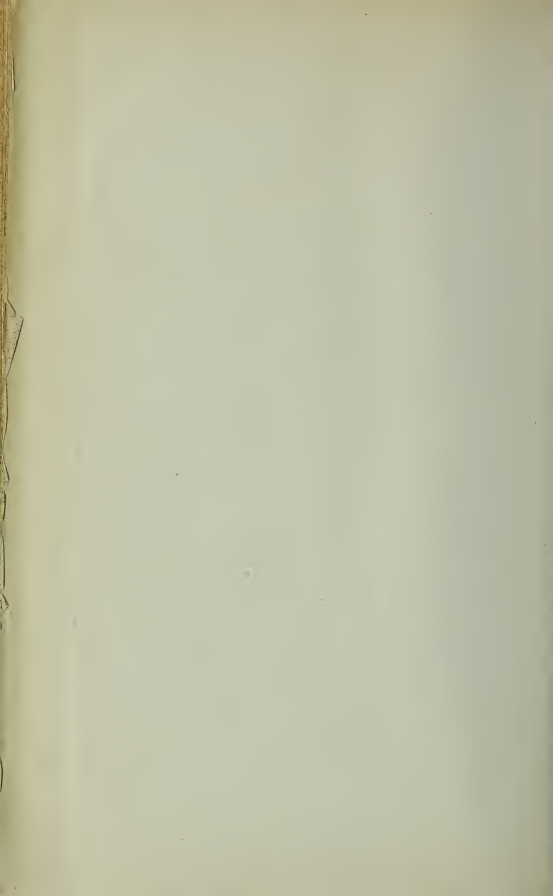
Richmond in 1900, looking southeast from Corner of Washington and Richmond Avenues.

Panorama of Portion of Richmond in 1912, looking southwest from Barrett Avenue and Fifteenth Street.
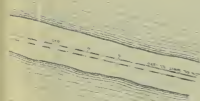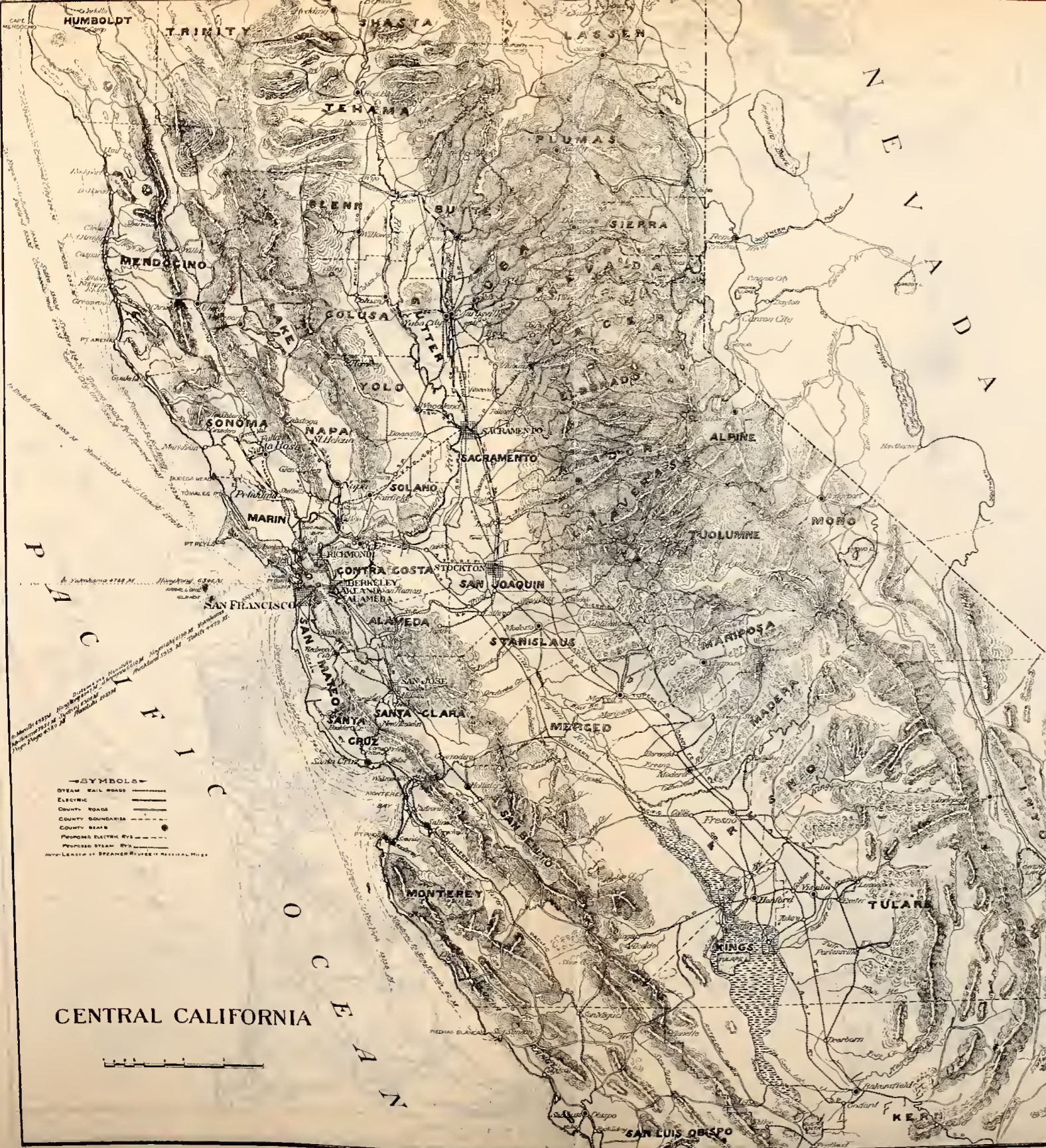
OCEAN TRADE ROUTES

RICHMOND
HARBOR PROJECT
CENTRAL CALIFORNIA
ITS RELATION TO
CERTAIN TRADE ROUTES
AND THE
PANAMA CANAL

SEPTEMBER 1912

Haviland & Tibbetts
Civil Engineers
San Francisco

CENTRAL CALIFORNIA

—SYMBOLS—
STEAM RAIL ROADS
ELECTRIC
COUNTY ROADS
COUNTY BOUNDARIES
COUNTY SEATS
PROPOSED ELECTRIC RY.
PROPOSED STEAM RY.

PLATE I

BAY CITIES & HARBOR HYDROGRAPHY
TRACED FROM U.S.C.&G.S. MAP OF SAN FRANCISCO ENTRANCE

SCALE OF MILES

DEPTHS GIVEN IN FEET BELOW MEAN LOWER LOW WATER (U.S.C.&G.S. DATUM)

RICHMOND
HARBOR PROJECT
HYDROGRAPHY WATERWAYS
AND
TRANSPORTATION LINES
OF
SAN FRANCISCO BAY
AND
VICINITY

SEPTEMBER 1912

Haviland & Tibbetts
Civil Engineers
San Francisco

PLATE 2

RICHMOND
HARBOR PROJECT
CITY OF RICHMOND
AND
VICINITY
CONTRA COSTA CO. CAL.
COMPILED FROM PRIVATE & OFFICIAL RECORDS MAPS
AND
ACTUAL SURVEYS

September 1912

Haviland and Tibbetts
Civil Engineers
San Francisco

SYMBOLS
STEAM RAILROADS
ELECTRIC RAILROADS
POWER LINES
PIPE LINES
SLOUGHS
TIDE LAND OWNERSHIP LINES
LANDS TO BE IMMEDIATELY
ACQUIRED BY THE CITY
LANDS TO BE EVENTUALLY
ACQUIRED BY THE CITY

PLATE-3.
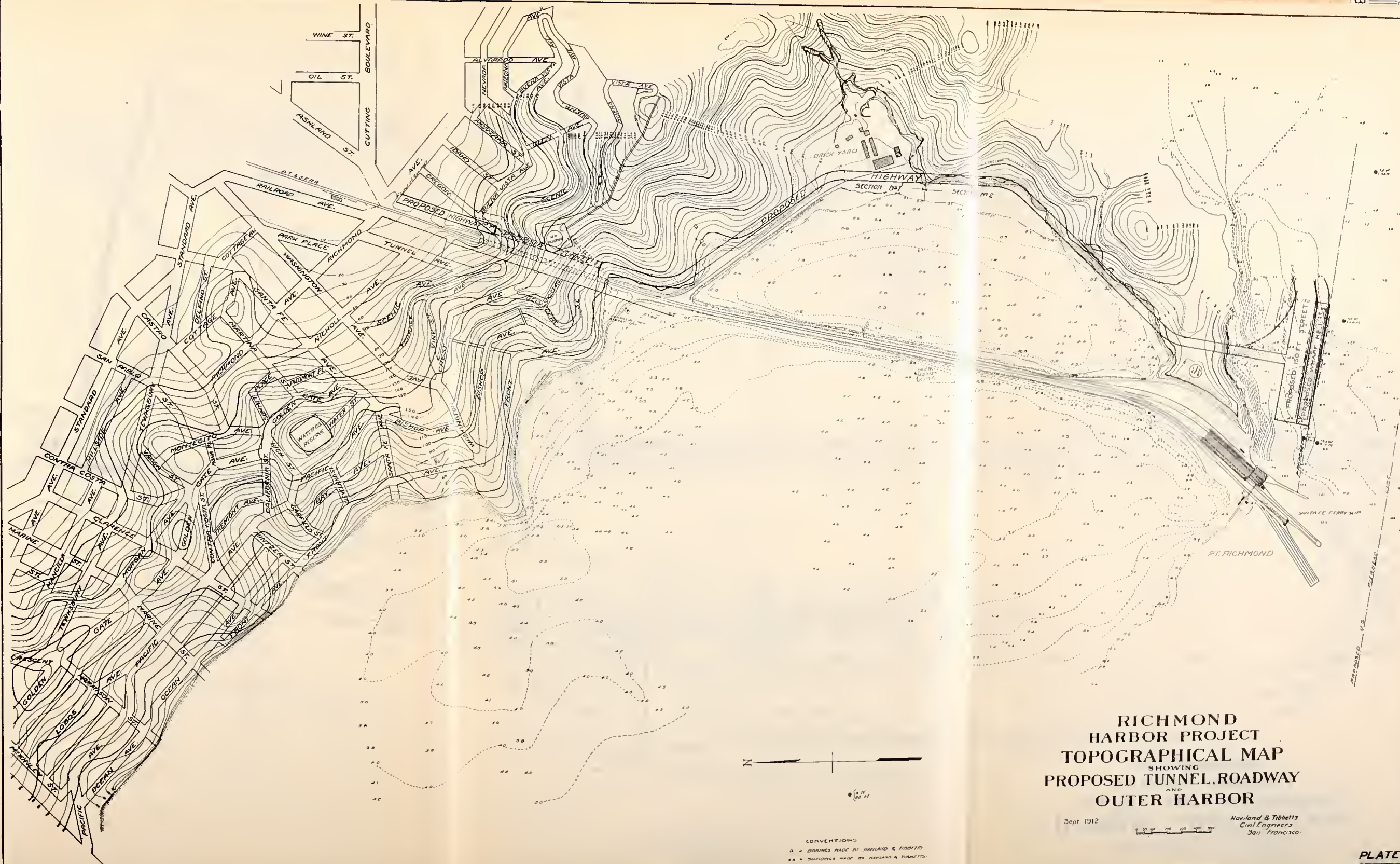
RICHMOND
HARBOR PROJECT
TOPOGRAPHICAL MAP
SHOWING
PROPOSED TUNNEL, ROADWAY
AND
OUTER HARBOR

Sept 1912

Haviland & Tibbetts
Civil Engineers
San Francisco

CONVENTIONS

PLATE-4

RICHMOND
HARBOR PROJECT
GENERAL PLAN OF PROPOSED
HARBOR MPROVEMENTS
CONFORMING TO HARBOR LINES
RECOMMENDED BY LIEUT. COL. REES U.S.E.D.

Sept 1912

Haviland & Tibbetts
Civil Engineers
San Francisco

PLATE. 5.
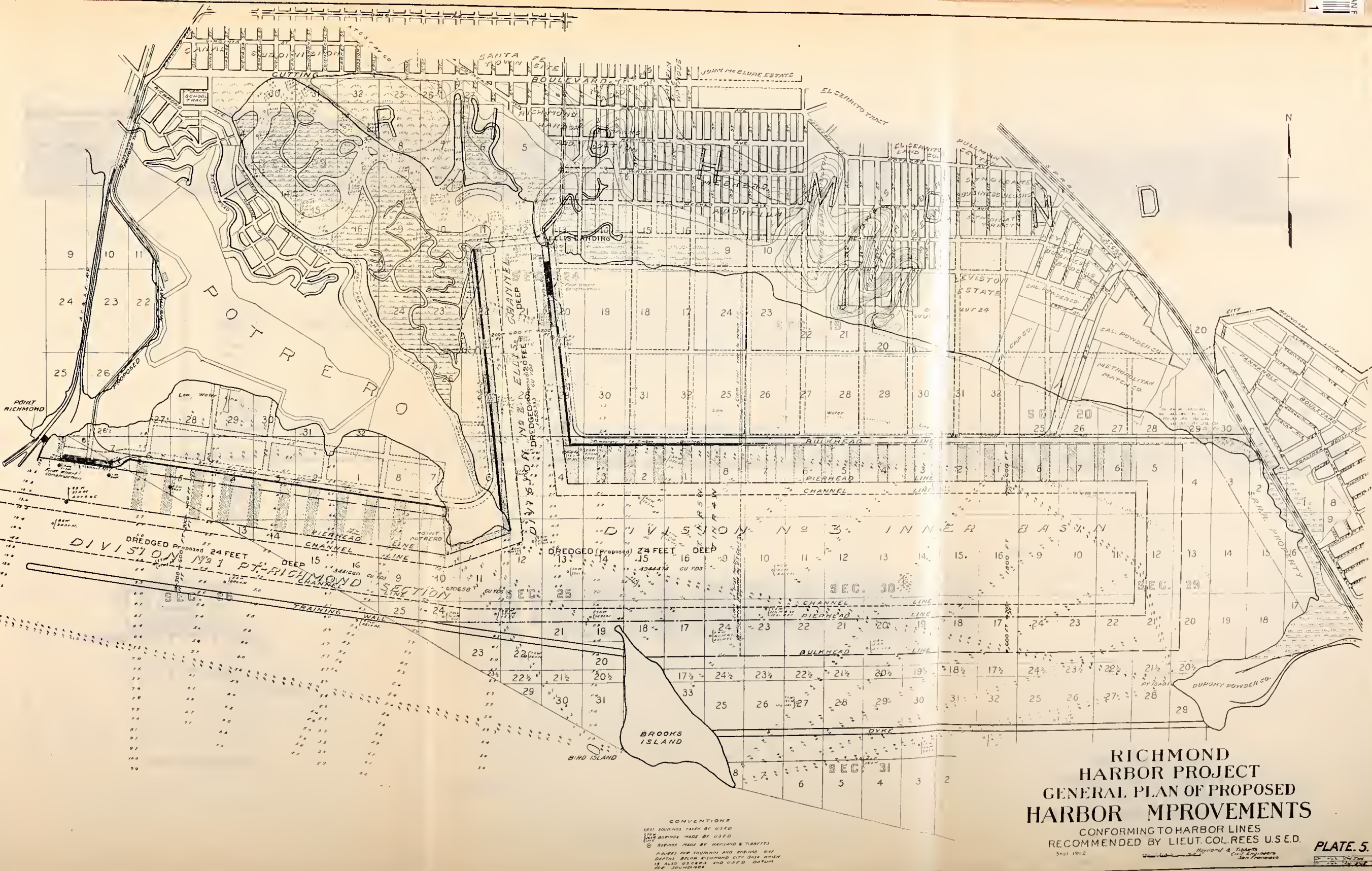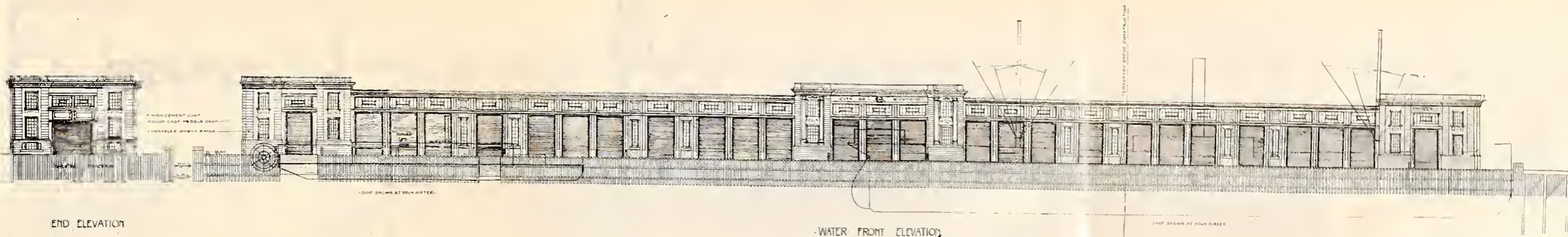
END ELEVATION

WATER FRONT ELEVATION
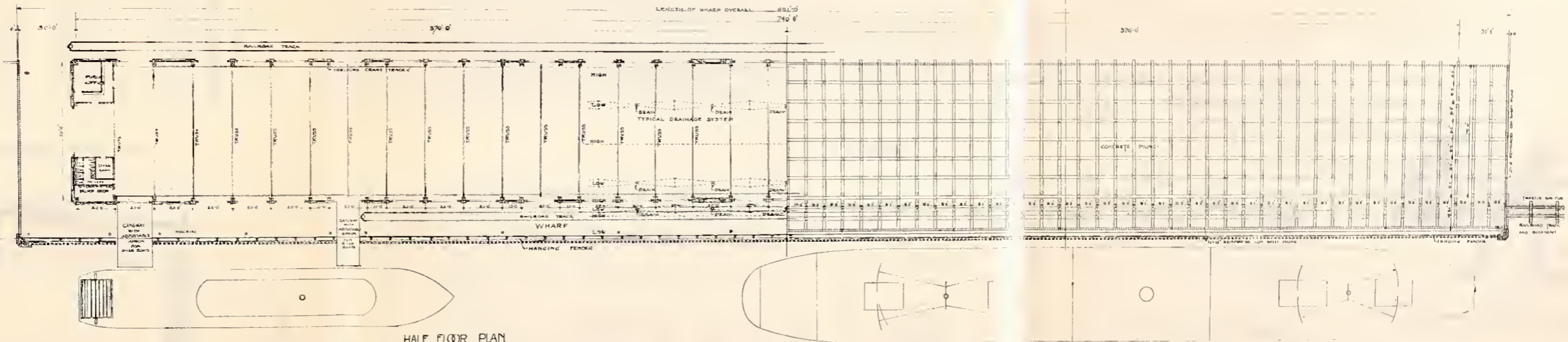
HALF FLOOR PLAN

HALF PLAN FLOOR FRAMING & PILING
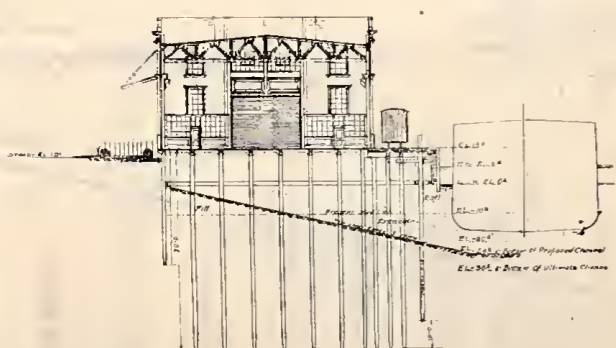
TYPICAL CROSS SECTION
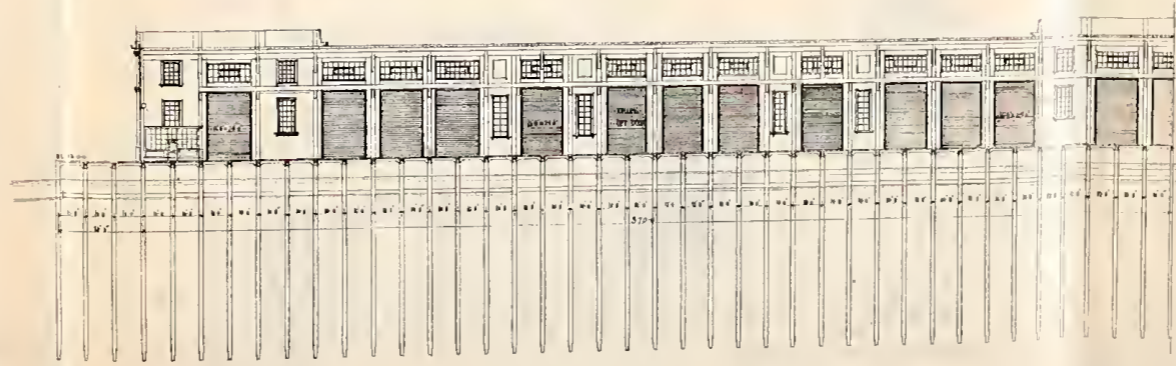
LONGITUDINAL SECTION ON CENTER LINE

RICHMOND
HARBOR PROJECT
GENERAL DESIGN
OUTER HARBOR WHARF Nº 1
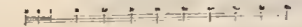
PLATE. 6.

SEPT 1912

HAVILAND & TIBBETTS
CIVIL ENGINEERS
SAN FRANCISCO

HALF ELEVATION OF SEAWALL & FLOATS
SMALL BOAT LANDING

SIDE ELEVATION FROM CHANNEL
ONE SHED AND ONE HALF OF WHARF

MAIN ROAD

HALF PLAN OF SEAWALL & FLOATS
SMALL BOAT LANDING

HALF PLAN FLOOR FRAMING & PILING

HALF PLAN SHED AND OPEN WHARF

TYPICAL CROSS SECTION

HALF LONGITUDINAL SECTION A.A

END ELEVATION OF SHED AND WHARF B.B
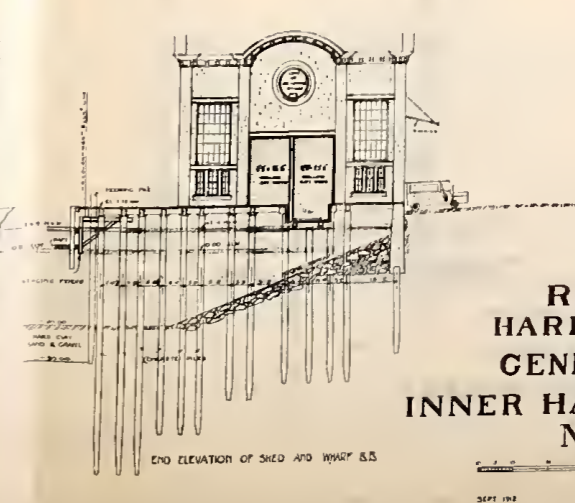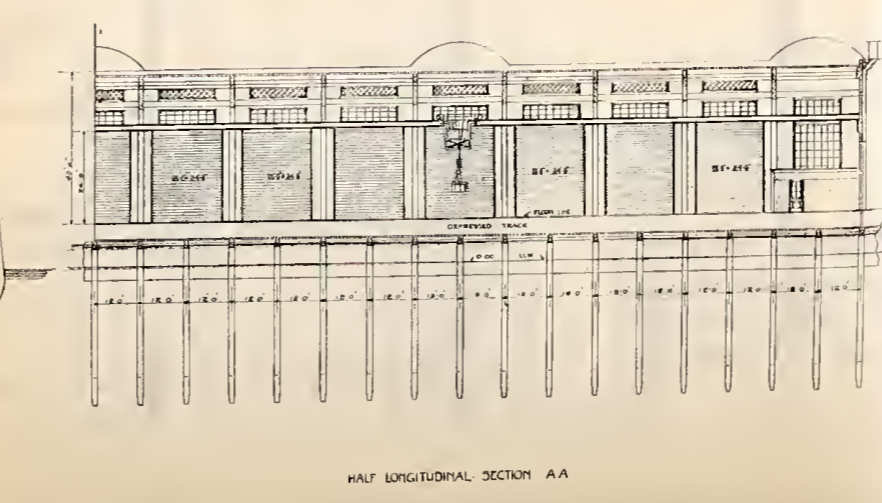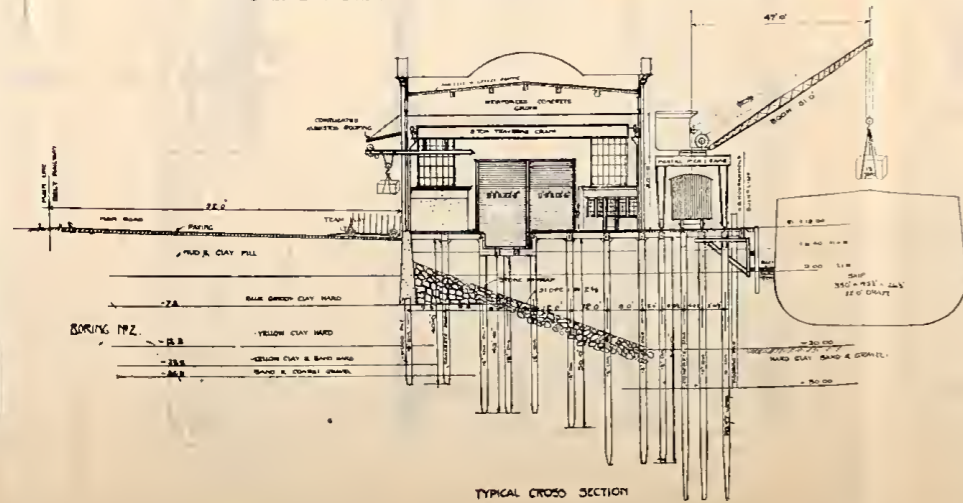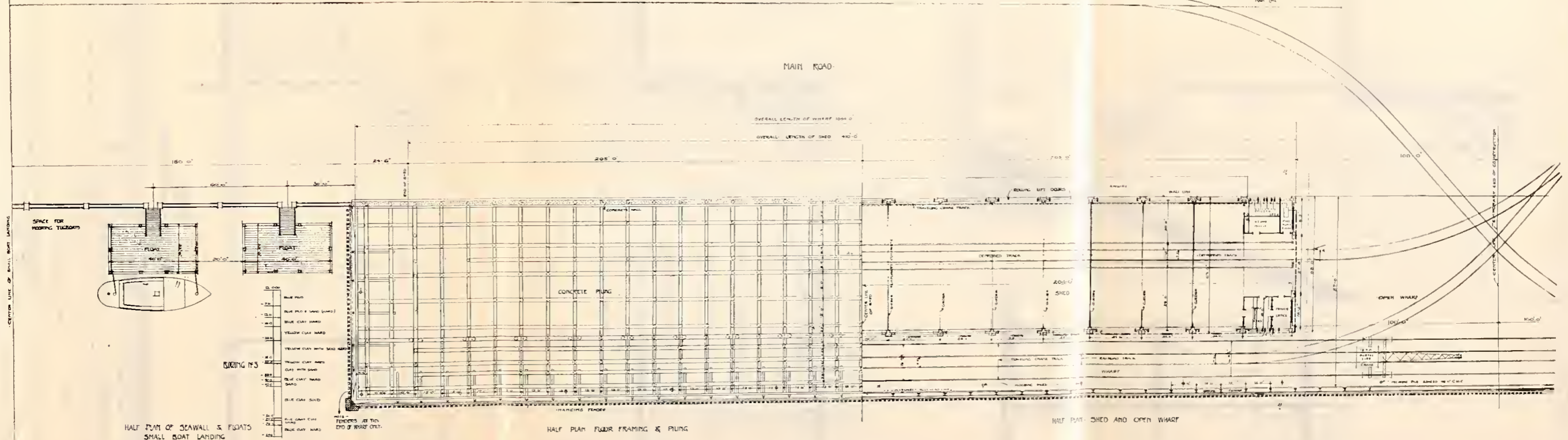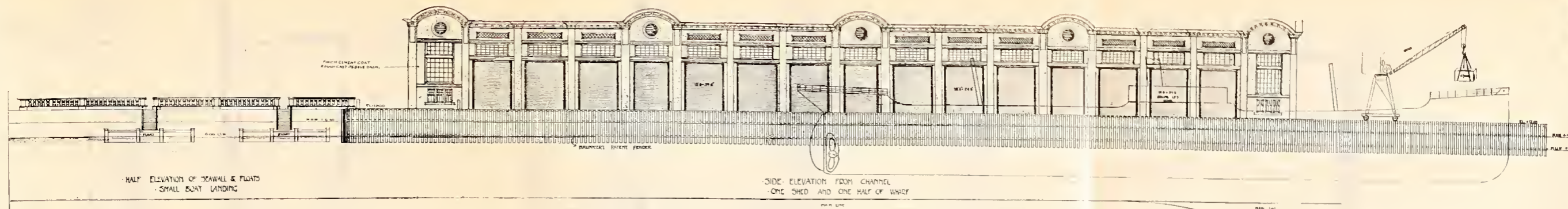
RICHMOND
HARBOR PROJECT
GENERAL DESIGN
INNER HARBOR WHARVES
Nos 2 and 3

PLATE. 8.
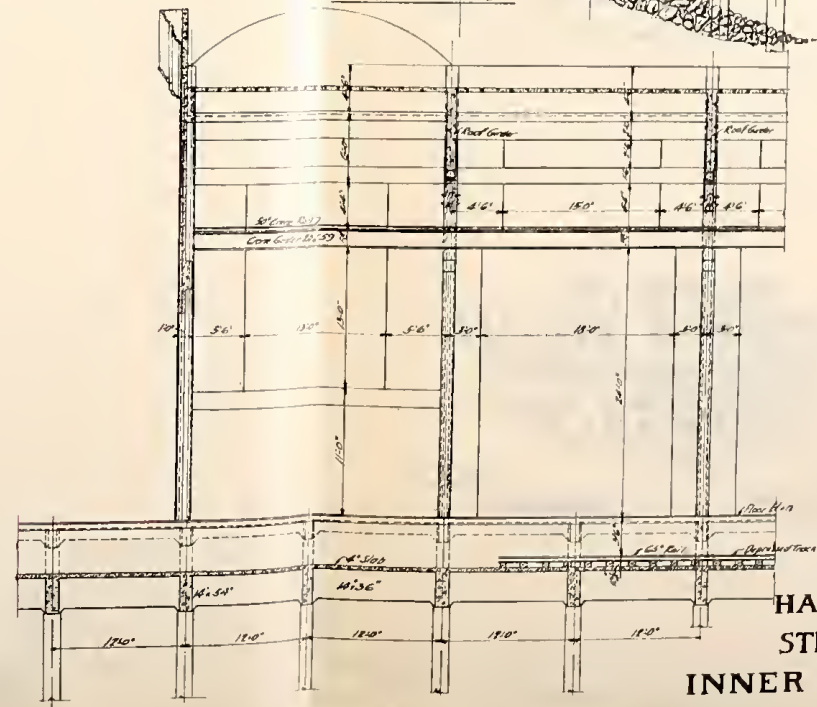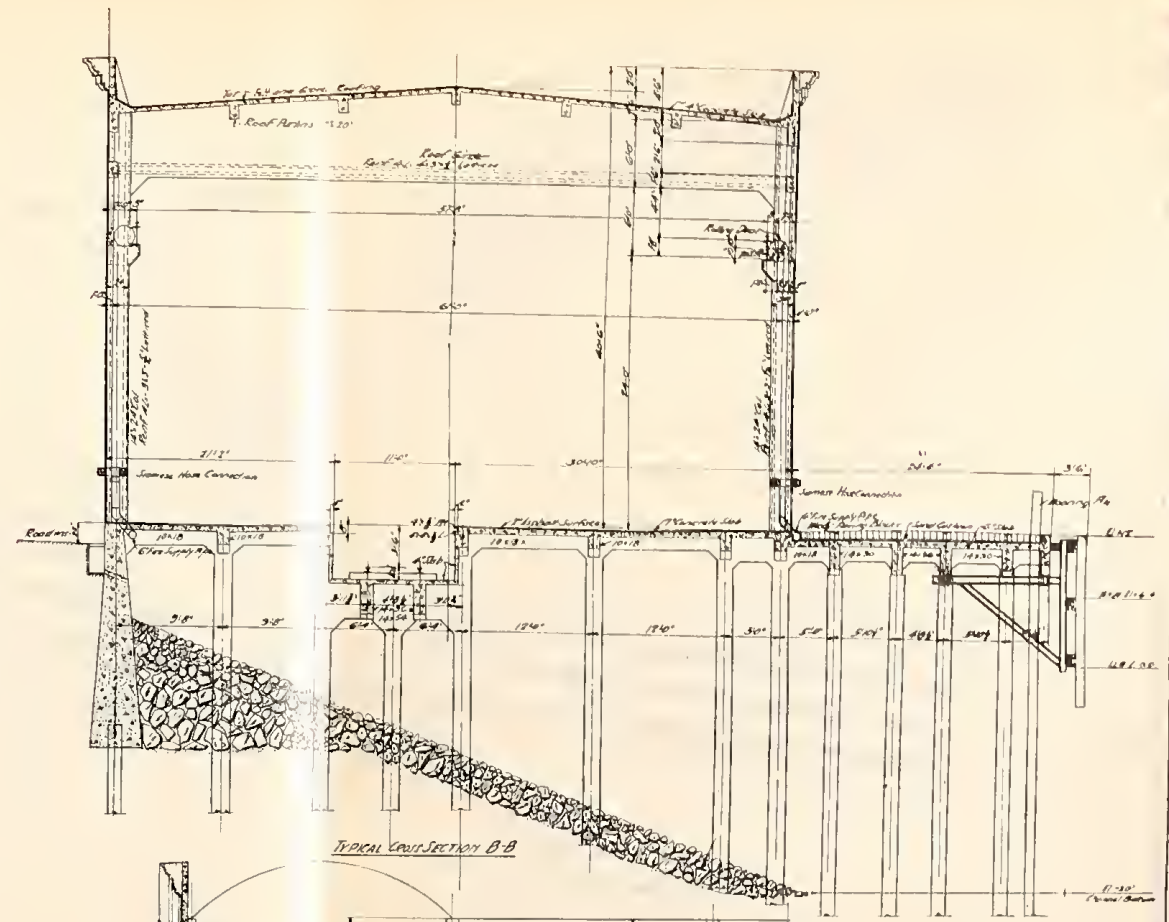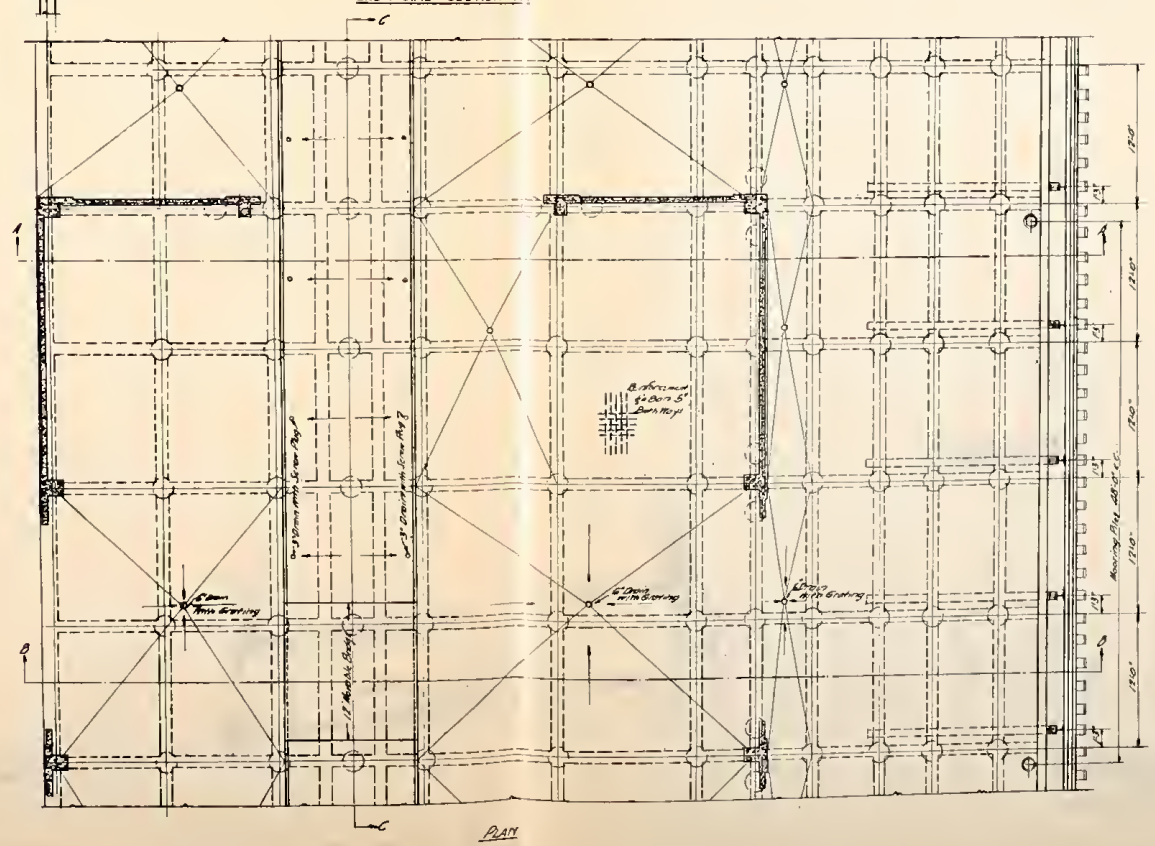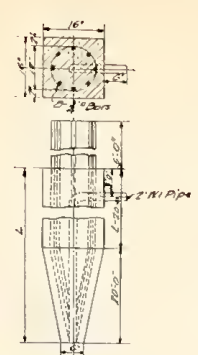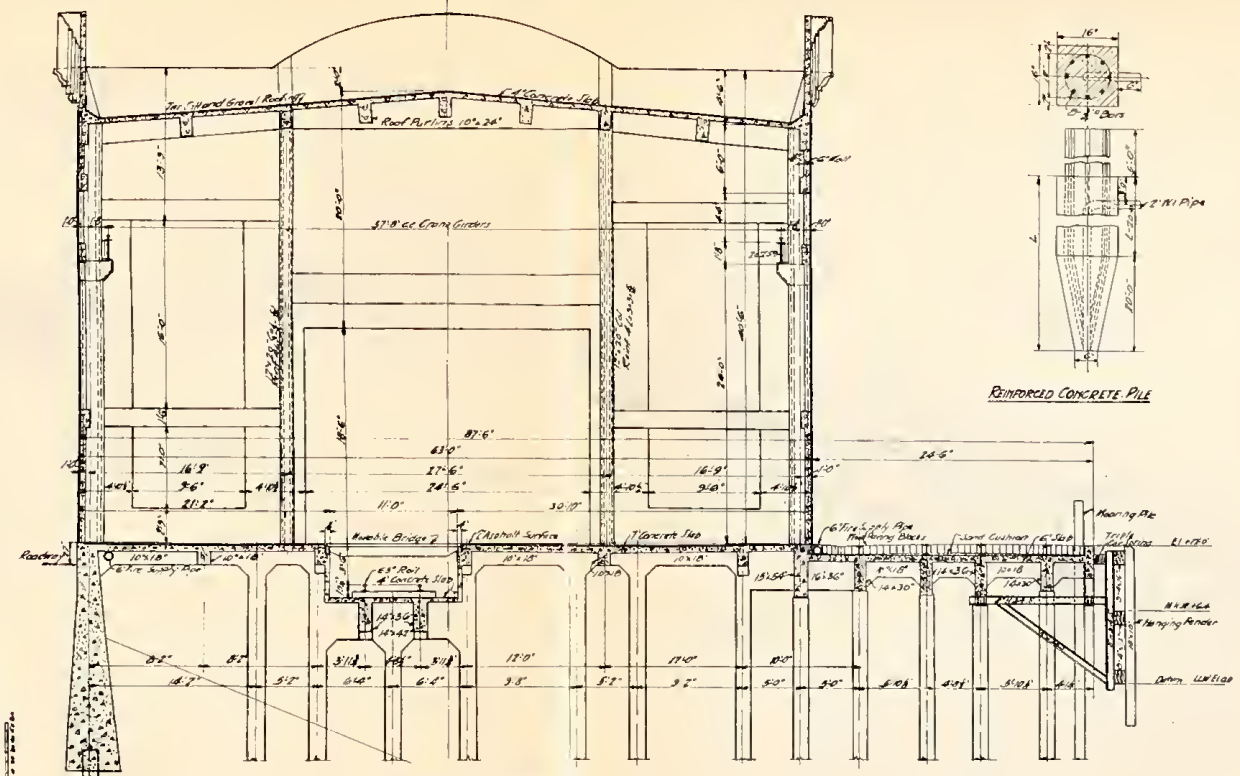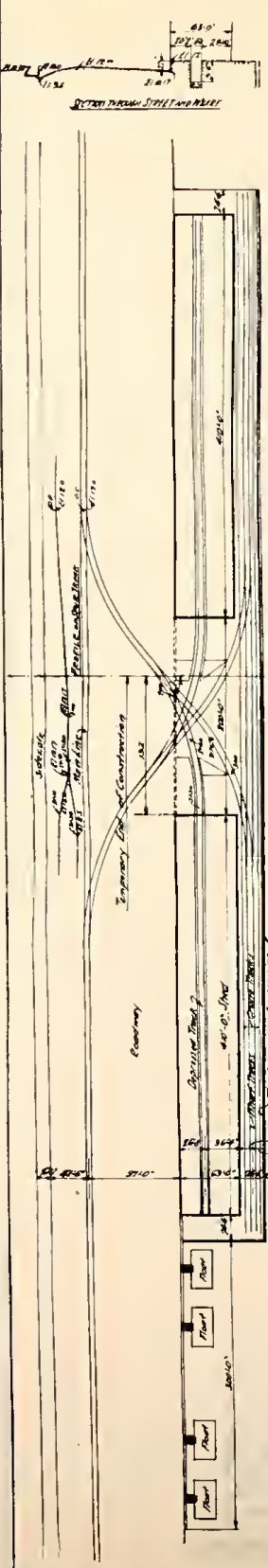
RICHMOND
HARBOR PROJECT
STRUCTURAL DESIGN
INNER HARBOR WHARVES
Nᵒˢ 2 ᴀɴᴅ 3

PLATE 9.
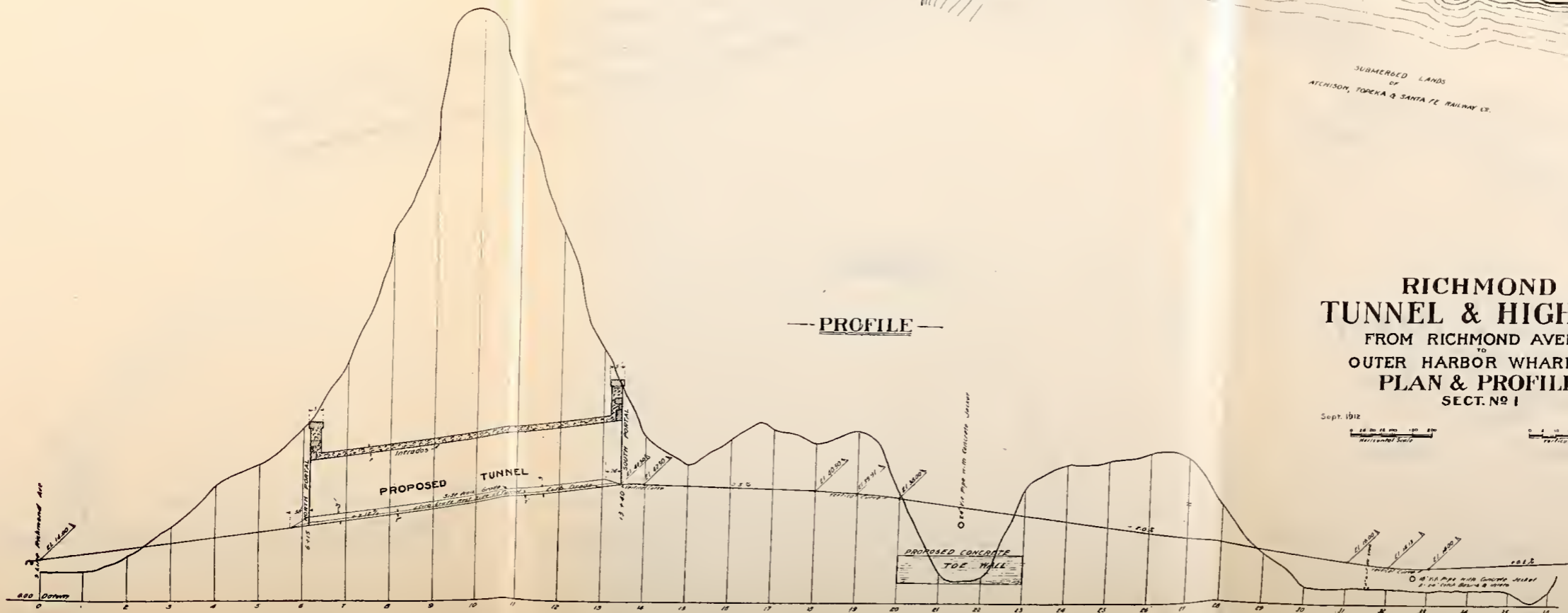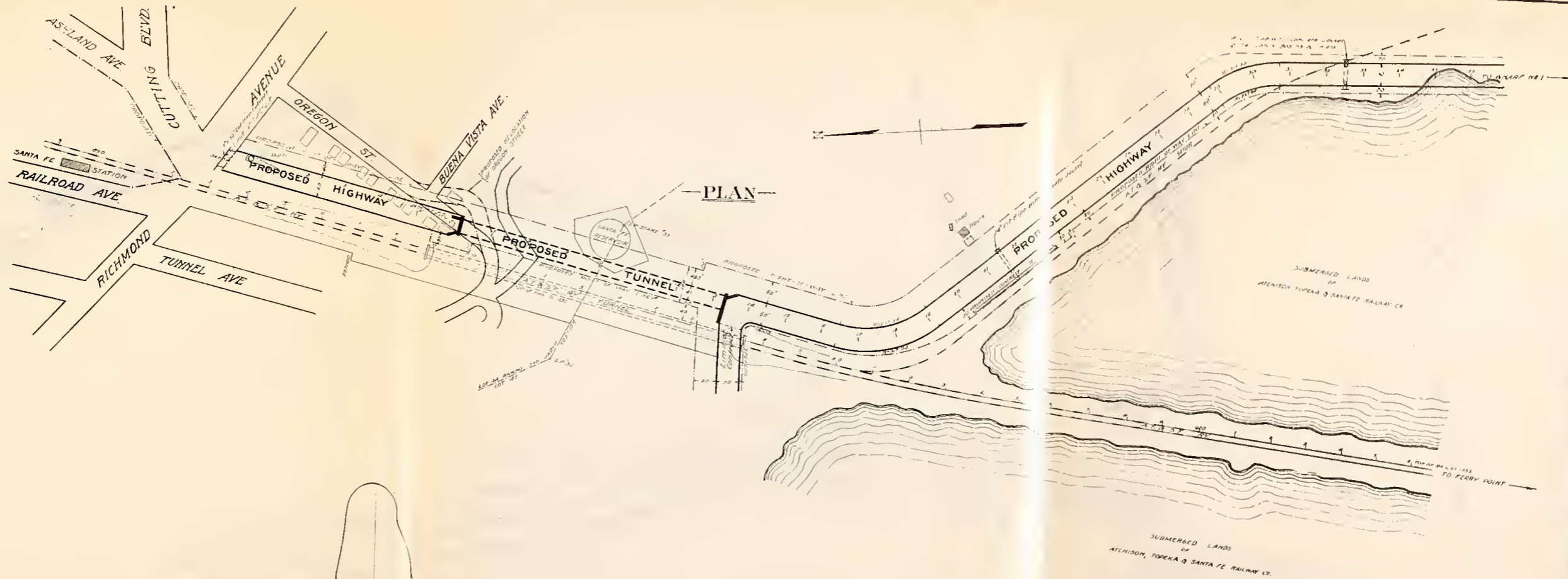
—PLAN—

—PROFILE—

**RICHMOND
TUNNEL & HIGHWAY**
FROM RICHMOND AVENUE
TO
OUTER HARBOR WHARF Nº1
PLAN & PROFILE
SECT. Nº 1

Sept. 1912

Haviland & Tibbetts
Civil Engineers
San Francisco

PLATE-10.

DETAIL OF CONDUIT, WALK & RAIL

MANHOLE COVER & FRAME

CURB GUARD
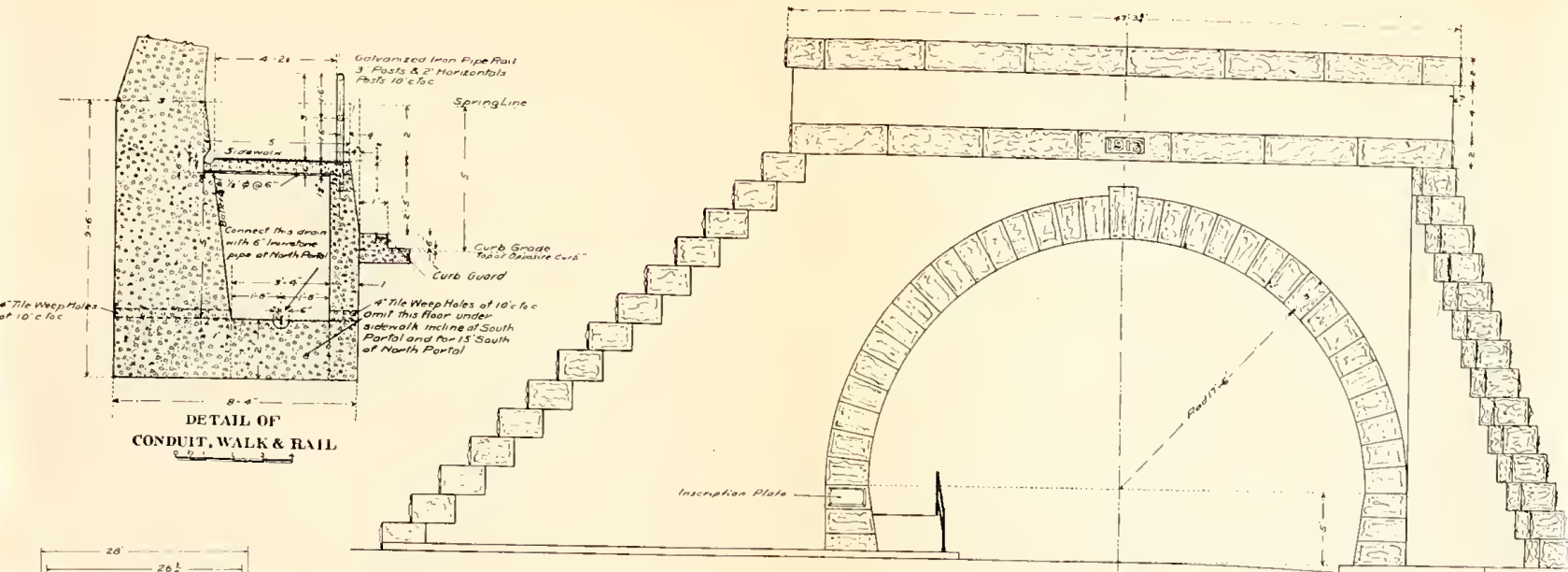
SOUTH PORTAL ~ ELEVATION
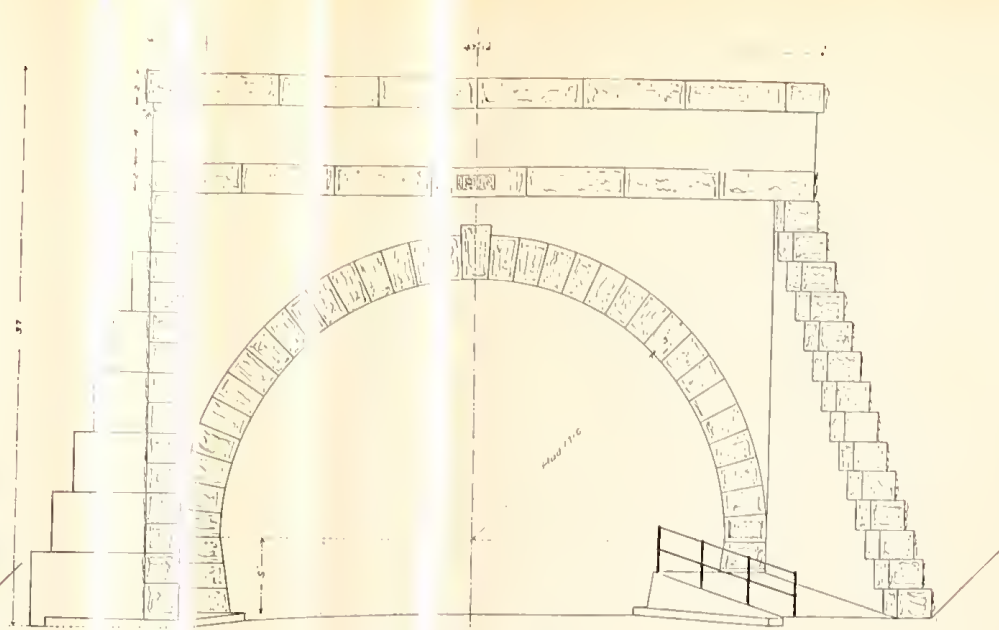
NORTH PORTAL ~ ELEVATION
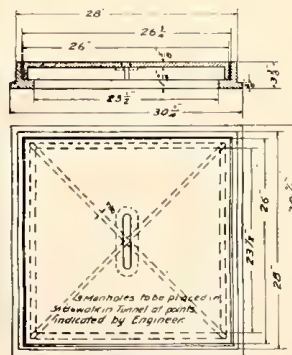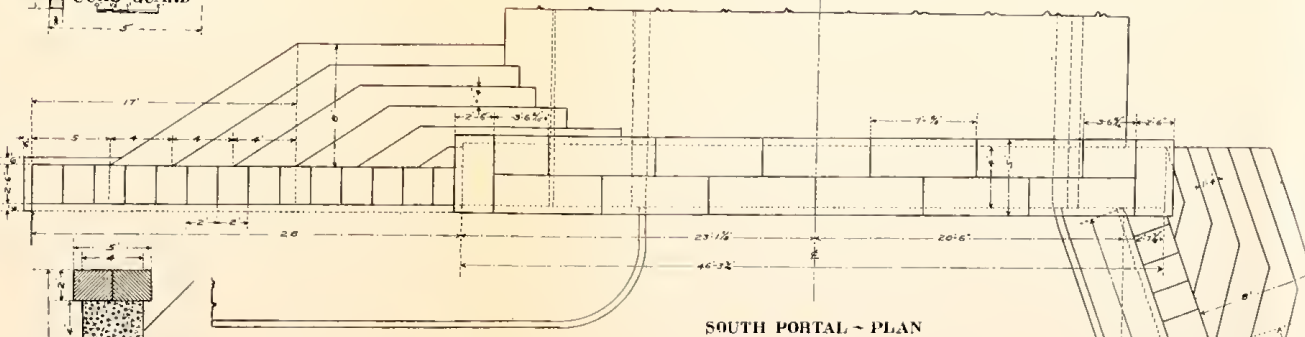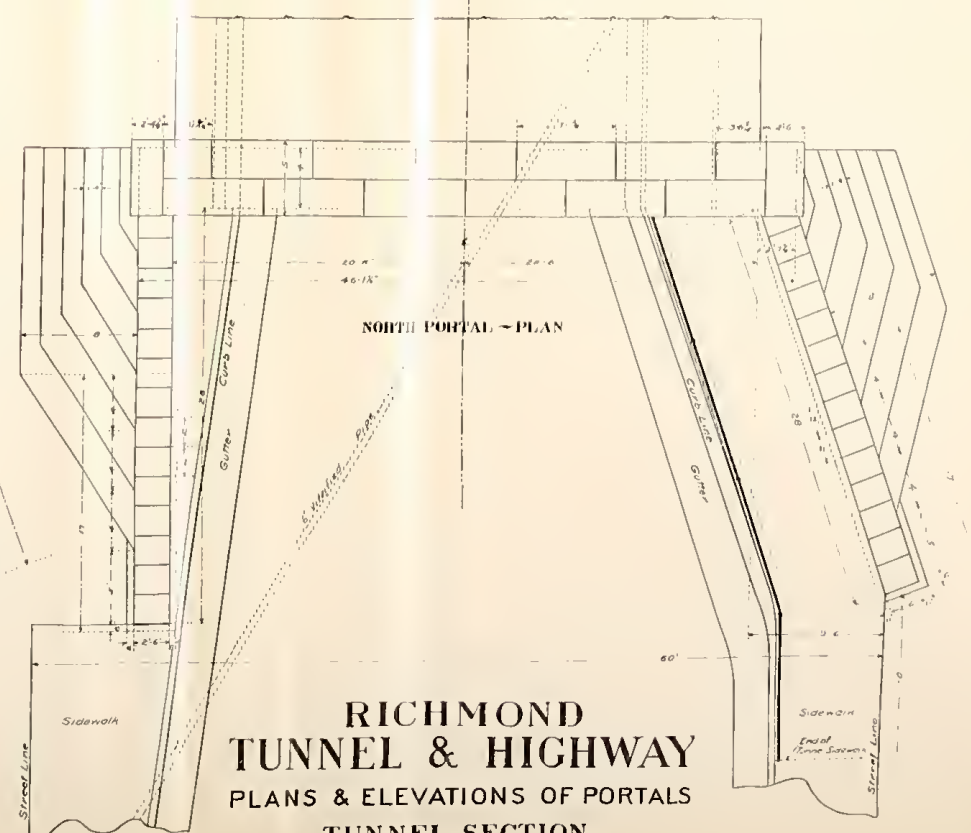
SOUTH PORTAL ~ PLAN

NORTH PORTAL ~ PLAN
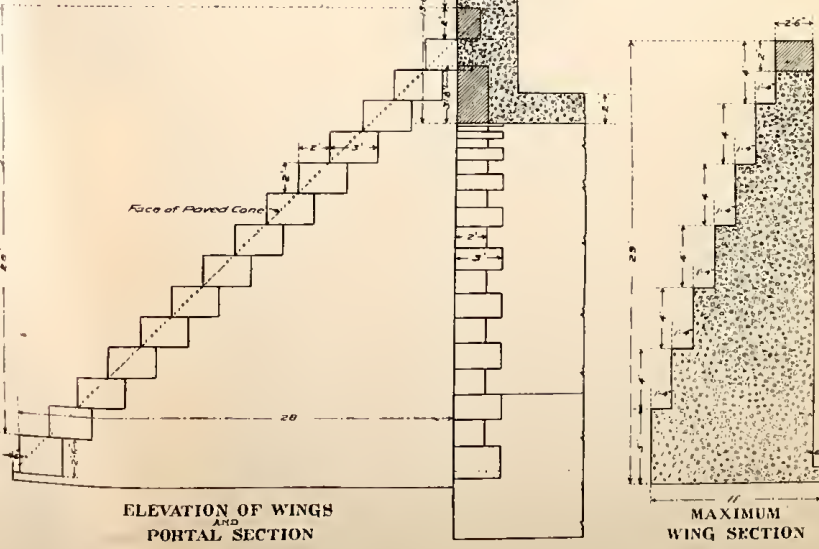
ELEVATION OF WINGS AND PORTAL SECTION
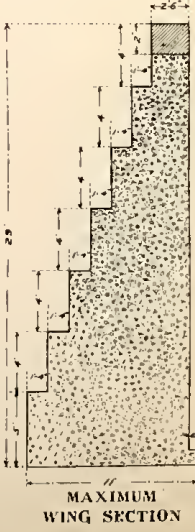
MAXIMUM WING SECTION
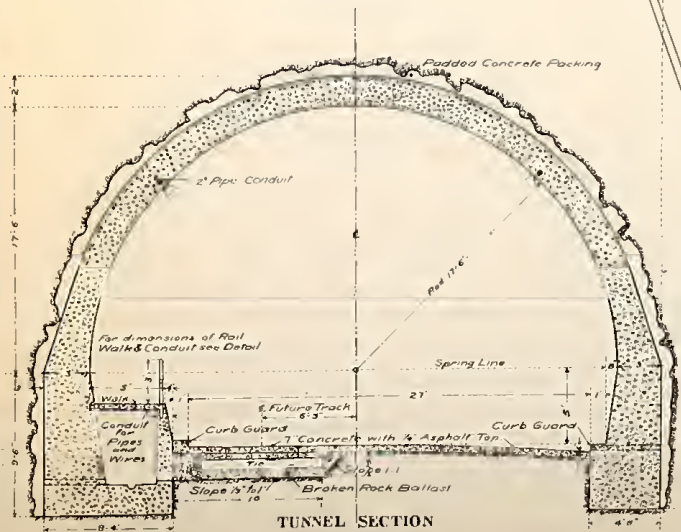
TUNNEL SECTION

RICHMOND
TUNNEL & HIGHWAY
PLANS & ELEVATIONS OF PORTALS
TUNNEL SECTION

Sept 1912

Haviland & Tibbitts
Civil Engineers
San Francisco

PLATE-12

DETAIL OF
CONDUIT, WALK & RAIL

CURB GUARD

MANHOLE
COVER & FRAME

MAXIMUM
WING SECTION
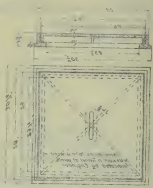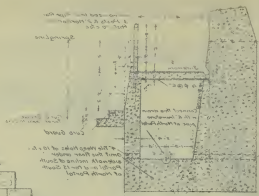
ELEVATION OF WINGS
PORTAL SECTION

DETAIL OF CORRUGATED CULVERT
Scale: 1"=1'

LONGITUDINAL SECTION   CROSS SECTION

CAST IRON GRATING

PLAN

CAST IRON CATCH BASIN

SECTION E-F

PLAN

ALTERNATE PAVEMENT

SECTION

CUTTING   BOULEVARD

OREGON STREET

PROPOSED   AVENUE

PROPOSED   HIGHWAY

PROPOSED   TUNNEL

PROPOSED   HIGHWAY

PROPOSED 150 FT. STREET

GENERAL PLAN

RAILROAD AVE

RICHMOND

HIGHWAY PLAN ~ NORTH OF TUNNEL

HIGHWAY SECTION ~ NORTH OF TUNNEL

CURB GUARD DETAIL

GUTTER DETAIL

HIGHWAY PLAN ~ SOUTH OF TUNNEL

HIGHWAY SECTION ~ SOUTH OF TUNNEL

CROSS SECTION   ELEVATION
CONCRETE TOE WALL STA. 20 & 23

TOE WALL PLAN

RICHMOND
TUNNEL & HIGHWAY
FROM RICHMOND AVENUE
TO
OUTER HARBOR WHARF Nº 1
CROSS SECTIONS, PLANS & DETAILS
OF
HIGHWAY SECTION

Sept 1912

Scales as noted

Haviland & Tibbetts
Civil Engineers
San Francisco

PLATE-13